BLUE VALLEY K-5 SCIENCE CURRICULUM

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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

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.

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 PS1

Matter and Its Interactions

Essential Question: How can one explain the structure, properties, and interactions of matter?

The existence of atoms, now supported by evidence from modern instruments, was first postulated as a model that could explain both qualitative and quantitative observations about matter (e.g., Brownian motion, ratios of reactants and products in chemical reactions). Matter can be understood in terms of the types of atoms present and the interactions both between and within them. The states (i.e., solid, liquid, gas, or plasma), properties (e.g., hardness, conductivity), and reactions (both physical and chemical) of matter can be described and predicted based on the types, interactions, and motions of the atoms within it. Chemical reactions, which underlie so many observed phenomena in living and nonliving systems alike, conserve the number of atoms of each type but change their arrangement into molecules. Nuclear reactions involve changes in the types of atomic nuclei present and are key to the energy release from the sun and the balance of isotopes in matter.

PS1.A: STRUCTURE AND PROPERTIES OF MATTER

Essential Question: How do particles combine to form the variety of matter one observes?

While too small to be seen with visible light, atoms have substructures of their own. They have a small central region or nucleus—containing protons and neutrons—surrounded by a larger region containing electrons. The number of protons in the atomic nucleus (atomic number) is the defining characteristic of each element; different isotopes of the same element differ in the number of neutrons only. Despite the immense variation and number of substances, there are only some 100 different stable elements.

Each element has characteristic chemical properties. The periodic table, a systematic representation of known elements, is organized horizontally by increasing atomic number and vertically by families of elements with related chemical properties. The development of the periodic table (which occurred well before atomic substructure was understood) was a major advance, as its patterns suggested and led to the identification of additional elements with particular properties. Moreover, the table's patterns are now recognized as related to the atom's outermost electron patterns, which play an important role in explaining chemical reactivity and bond formation, and the periodic table continues to be a useful way to organize this information.

The substructure of atoms determines how they combine and rearrange to form all of the world's substances. Electrical attractions and repulsions between charged particles (i.e., atomic nuclei and electrons) in matter explain the structure of atoms and the forces between atoms that cause them to form molecules (via chemical bonds), which range in size from two to thousands of atoms (e.g., in biological molecules such as proteins). Atoms also combine due to these forces to form extended structures, such as crystals or metals. The varied properties (e.g., hardness, conductivity) of the materials one encounters, both natural and manufactured, can be understood in terms of the atomic and molecular constituents present and the forces within and between them. Within matter, atoms and their constituents are constantly in motion. The arrangement and motion of atoms vary in characteristic ways, depending on the substance and its current state (e.g., solid, liquid). Chemical composition, temperature, and pressure affect such arrangements and motions of atoms, as well as the ways in which they interact. Under a given set of conditions, the state and some properties (e.g., density, elasticity, viscosity) are the same for different bulk quantities of a substance, whereas other properties (e.g., volume, mass) provide measures of the size of the sample at hand.

Materials can be characterized by their intensive measureable properties. Different materials with different properties are suited to different uses. The ability to image and manipulate placement of individual atoms in tiny structures allows for the design of new types of materials with particular desired functionality (e.g., plastics, nanoparticles). Moreover, the modern explanation of how particular atoms influence the properties of materials or molecules is critical to understanding the physical and chemical functioning of biological systems.

Grade Band Endpoints for PS1.A

By the end of grade 2. Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties (e.g., visual, aural, textural), by its uses, and by whether it occurs naturally or is manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces (e.g., blocks, construction sets). Objects or samples of a substance can be weighed, and their size can be described and measured. (Boundary: volume is introduced only for liquid measure.)

By the end of grade 5. Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). For example, a model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects (e.g., leaves in wind, dust suspended in air); and the appearance of visible scale water droplets in condensation, fog, and, by extension, also in clouds or the contrails of a jet. The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (e.g., sugar in solution, evaporation in a closed container). Measurements of a variety of properties (e.g., hardness, reflectivity) can be used to identify particular materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)

PS1.B: CHEMICAL REACTIONS

Essential Question: How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?

Many substances react chemically with other substances to form new substances with different properties. This change in properties results from the ways in which atoms from the original substances are combined and rearranged in the new substances. However, the total number of each type of atom is conserved (does not change) in any chemical process, and thus mass does not change either. The property of conservation can be used, along with knowledge of the chemical properties of particular elements, to describe and predict the outcomes of reactions. Changes in matter in which the molecules do not change, but their positions and their motion relative to each other do change also occur (e.g., the forming of a solution,a change of state). Such changes are generally easier to reverse (return to original conditions) than chemical changes.

“Collision theory” provides a qualitative model for explaining the rates of chemical reactions. Higher rates occur at higher temperatures because atoms are typically moving faster and thus collisions are more frequent; also, a larger fraction of the collisions have sufficient energy to initiate the process. Although a solution or a gas may have constant chemical composition—that is, be in a steady state—chemical reactions may be occurring within it that are dynamically balanced with reactions in opposite directions proceeding at equal rates.

Any chemical process involves a change in chemical bonds and the related bond energies and thus in the total chemical binding energy. This change is matched by a difference between the total kinetic energy of the set of reactant molecules before the collision and that of the set of product molecules after the collision (conservation of energy). Some reactions release energy (e.g., burning fuel in the presence of oxygen), and others require energy input (e.g., synthesis of sugars from carbon dioxide and water).

Understanding chemical reactions and the properties of elements is essential not only to the physical sciences but also is foundational knowledge for the life sciences and the earth and space sciences. The cycling of matter and associated transfers of energy in systems, of any scale, depend on physical and chemical processes. The reactivity of hydrogen ions gives rise to many biological and geophysical phenomena. The capacity of carbon atoms to form the backbone of extended molecular structures is essential to the chemistry of life. The carbon cycle involves transfers between carbon in the atmosphere—in the form of carbon dioxide—and carbon in living matter or formerly living matter (including fossil fuels). The proportion of oxygen molecules (i.e., oxygen in the form O_2) in the atmosphere also changes in this cycle.

Grade Band Endpoints for PS1.B

By the end of grade 2. Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible (e.g., melting and freezing), and sometimes they are not (e.g., baking a cake, burning fuel).

By the end of grade 5. When two or more different substances are mixed, a new substance with different properties may be formed; such occurrences depend on the substances and the temperature. No matter what reaction or
change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)

Core Idea PS2

Motion and Stability: Forces and Interactions

Essential Question: How can one explain and predict interactions between objects and within systems of objects?

Interactions between any two objects can cause changes in one or both of them. An understanding of the forces between objects is important for describing how their motions change, as well as for predicting stability or instability in systems at any scale. All forces between objects arise from a few types of interactions: gravity, electromagnetism, and the strong and weak nuclear interactions.

PS2.A: FORCES AND MOTION

Essential Question: How can one predict an object's continued motion, changes in motion, or stability?

Interactions of an object with another object can be explained and predicted using the concept of forces, which can cause a change in motion of one or both of the interacting objects. An individual force acts on one particular object and is described by its strength and direction. The strengths of forces can be measured and their values compared.

What happens when a force is applied to an object depends not only on that force but also on all the other forces acting on that object. A static object typically has multiple forces acting on it, but they sum to zero. If the total (vector sum) force on an object is not zero, however, its motion will change. Sometimes forces on an object can also change its shape or orientation. For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first but in the opposite direction (Newton's third law).

At the macroscale, the motion of an object subject to forces is governed by Newton's second law of motion. Under everyday circumstances, the mathematical expression of this law in the form $F = ma$ (total force = mass times acceleration) accurately predicts changes in the motion of a single macroscopic object of a given mass due to the total force on it. But at speeds close to the speed of light, the second law is not applicable without modification. Nor does it apply to objects at the molecular, atomic, and subatomic scales, or to an object whose mass is changing at the same time as its speed.

For speeds that are small compared with the speed of light, the momentum of an object is defined as its mass times its velocity. For any system of interacting objects, the total momentum within the system changes only due to transfer of momentum into or out of the system, either because of external forces acting on the system or because of matter flows. Within an isolated system of interacting objects, any change in momentum of one object is balanced by an equal and oppositely directed change in the total momentum of the other objects. Thus total momentum is a conserved quantity.

Grade Band Endpoints for PS2.A

By the end of grade 2. Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.

By the end of grade 5. Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) The patterns of an object's motion in various situations can be observed and measured; when past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

PS2.B: TYPES OF INTERACTIONS

Essential Question: What underlying forces explain the variety of interactions observed?

All forces between objects arise from a few types of interactions: gravity, electromagnetism, and strong and weak nuclear interactions. Collisions between objects involve forces between them that can change their motion. Any two objects in contact also exert forces on each other that are electromagnetic in origin. These forces result from deformations of the objects' substructures and the electric charges of the particles that form those substructures (e.g., a table supporting a book, friction forces).

Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact. These forces are explained by force fields that contain energy and can transfer energy through space. These fields can be mapped by their effect on a test object (mass, charge, or magnet, respectively).

Objects with mass are sources of gravitational fields and are affected by the gravitational fields of all other objects with mass. Gravitational forces are always attractive. For two human-scale objects, these forces are too small to observe without sensitive instrumentation. Gravitational interactions are nonnegligible, however, when very massive objects are involved. Thus the gravitational force due to Earth, acting on an object near Earth's surface, pulls that object toward the planet's center. Newton's law of universal gravitation provides the mathematical model to describe and predict the effects of gravitational forces between distant objects. These long-range gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (e.g., the solar system, galaxies) and the patterns of motion within them.

Electric forces and magnetic forces are different aspects of a single electromagnetic interaction. Such forces can be attractive or repulsive, depending on the relative sign of the electric charges involved, the direction of current flow, and the orientation of magnets. The forces' magnitudes depend on the magnitudes of the charges, currents, and magnetic strengths as well as on the distances between the interacting objects. All objects with electrical charge or magnetization are sources of electric or magnetic fields and can be affected by the electric or magnetic fields of other such objects. Attraction and repulsion of electric charges at the atomic scale explain the structure, properties, and transformations of matter and the contact forces between material objects (link to PS1.A and PS1.B). Coulomb's law provides the mathematical model to describe and predict the effects of electrostatic forces (relating to stationary electric charges or fields) between distant objects.

The strong and weak nuclear interactions are important inside atomic nuclei. These short-range interactions determine nuclear sizes, stability, and rates of radioactive decay (see PS1.C).

Grade Band Endpoints for PS2.B

By the end of grade 2. When objects touch or collide, they push on one another and can change motion or shape.

By the end of grade 5. Objects in contact exert forces on each other (friction, elastic pushes and pulls). Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

PS2.C: STABILITY AND INSTABILITY IN PHYSICAL SYSTEMS

Essential Question: Why are some physical systems more stable than others?

Events and processes in a system typically involve multiple interactions occurring simultaneously or in sequence. The system's stability or instability and its rate of evolution depend on the balance or imbalance among these multiple effects.

A stable system is one in which the internal and external forces are such that any small change results in forces that return the system to its prior state (e.g., a weight hanging from a string). A system can be static but unstable, with any small change leading to forces that tend to increase that change (e.g., a ball at the top of a hill). A system can be changing but have a stable repeating cycle of changes, with regular patterns of change that allow predictions about the system's future (e.g., Earth orbiting the sun). And a stable system can appear to be unchanging when flows or processes within it are going on at opposite but equal rates (e.g., water in a dam at a constant height but with water flowing in that offsets the water flowing out; a person maintaining steady weight but eating food, burning calories, and excreting waste).

Stability and instability in any system depend on the balance of competing effects. A steady state of a complex system can be maintained through a set of feedback mechanisms, but changes in conditions can move the system out of its range of stability (e.g., homeostasis breaks down at too high or too low a temperature). With no energy inputs, a system starting out in an unstable state will continue to change until it reaches a stable configuration (e.g., the temperatures of hot and cold objects in contact). Viewed at a given scale, stable systems may appear static or dynamic. Conditions and properties of the objects within a system affect the rates of energy transfer and thus how fast or slowly a process occurs (e.g., heat conduction, the diffusion of particles in a fluid).

When a system has a great number of component pieces, one may not be able to predict much about its precise future. For such systems (e.g., with very many colliding molecules), one can often predict average but not detailed properties and behaviors (e.g., average temperature, motion, and rates of chemical change but not the trajectories of particular molecules).

Grade Band Endpoints for PS2.C

By the end of grade 2. Whether an object stays still or moves often depends on the effects of multiple pushes and pulls on it (e.g., multiple players trying to pull an object in different directions). It is useful to investigate what pushes and pulls keep something in place (e.g., a ball on a slope, a ladder leaning on a wall) as well as what makes something change or move.

By the end of grade 5. A system can change as it moves in one direction (e.g., a ball rolling down a hill), shifts back and forth (e.g., a swinging pendulum), or goes through cyclical patterns (e.g., day and night). Examining how the forces on and within the system change as it moves can help to explain the system's patterns of change.

A system can appear to be unchanging when processes within the system are occurring at opposite but equal rates (e.g., water behind a dam is at a constant height because water is flowing in at the same rate that water is flowing out). Changes can happen very quickly or very slowly and are sometimes hard to see (e.g., plant growth). Conditions and properties of the objects within a system affect how fast or slowly a process occurs (e.g., heat conduction rates).

Core Idea PS3

Energy

Essential Question: How is energy transferred and conserved?

Interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another. The total energy within a defined system changes only by the transfer of energy into or out of the system.

PS3.A: DEFINITIONS OF ENERGY

Essential Question: What is energy?

That there is a single quantity called energy is due to the remarkable fact that a system's *total* energy is conserved. Regardless of the quantities of energy transferred between subsystems and stored in various ways within the system, the total energy of a system changes only by the amount of energy transferred into and out of the system.

At the macroscopic scale, energy manifests itself in multiple phenomena, such as motion, light, sound, electrical and magnetic fields, and thermal energy. Historically, different units were introduced for the energy present in these different phenomena, and it took some time before the relationships among them were recognized. Energy is best understood at the microscopic scale, at which it can be modeled as either motions of particles or as stored in force fields (electric, magnetic, gravitational) that mediate interactions between particles. This last concept includes electromagnetic radiation, a phenomenon in which energy stored in fields moves across space (light, radio waves) with no supporting matter medium.

Motion energy is also called kinetic energy; defined in a given reference frame, it is proportional to the mass of the moving object and grows with the square of its speed. Matter at any temperature above absolute zero contains thermal energy. Thermal energy is the random motion of particles (whether vibrations in solid matter or molecules or free motion in a gas), this energy is distributed among all the particles in a system through collisions and interactions at a distance. In contrast, a sound wave is a moving pattern of particle vibrations that transmits energy through a medium.

Electric and magnetic fields also contain energy; any change in the relative positions of charged objects (or in the positions or orientations of magnets) changes the fields between them and thus the amount of energy stored in those fields. When a particle in a molecule of solid matter vibrates, energy is continually being transformed back and forth between the energy of motion and the energy stored in the electric and magnetic fields within the matter. Matter in a stable form minimizes the stored energy in the electric and magnetic fields within it; this defines the equilibrium positions and spacing of the atomic nuclei in a molecule or an extended solid and the form of their combined electron charge distributions (e.g., chemical bonds, metals).

Energy stored in fields within a system can also be described as potential energy. For any system where the stored energy depends only on the spatial configuration of the system and not on its history, potential energy is a useful concept (e.g., a massive object above Earth's surface, a compressed or stretched spring). It is defined as a difference in energy compared to some arbitrary reference configuration of a system. For example, lifting an object increases the stored energy in the gravitational field between that object and Earth (gravitational potential energy) compared to that for the object at Earth's surface; when the object falls, the stored energy decreases and the object's kinetic energy increases. When a pendulum swings, some stored energy is transformed into kinetic energy and back again into stored energy during each swing. (In both examples energy is transferred out of the system due to collisions with air and for the pendulum also by friction in its support.) Any change in potential energy is accompanied by changes in other forms of energy within the system, or by energy transfers into or out of the system. Electromagnetic radiation (such as light and X-rays) can be modeled as a wave of changing electric and magnetic fields. At the subatomic scale (i. e., in quantum theory), many phenomena involving electromagnetic radiation (e.g., photoelectric effect) are best modeled as a stream of particles called photons. Electromagnetic radiation from the sun is a major source of energy for life on Earth.

The idea that there are different forms of energy, such as thermal energy, mechanical energy, and chemical energy, is misleading, as it implies that the nature of the energy in each of these manifestations is distinct when in fact they all are ultimately, at the atomic scale, some mixture of kinetic energy, stored energy, and radiation. It is likewise misleading to call sound or light a form of energy; they are phenomena that, among their other properties, transfer energy from place to place and between objects.

Grade Band Endpoints for PS3.A

By the end of grade 2. **[**Intentionally left blank.]

By the end of grade 5. The faster a given object is moving, the more energy it possesses. Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.)

PS3.B: CONSERVATION OF ENERGY AND ENERGY TRANSFER

Essential Questions: What is meant by conservation of energy?
How is energy transferred between objects or systems?

The total change of energy in any system is always equal to the total energy transferred into or out of the system. This is called conservation of energy. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Many different types of phenomena can be explained in terms of energy transfers. Mathematical expressions, which quantify changes in the forms of energy within a system and transfers of energy into or out of the system, allow the concept of conservation of energy to be used to predict and describe the behavior of a system.

When objects collide or otherwise come in contact, the motion energy of one object can be transferred to change the motion or stored energy (e.g., change in shape or temperature) of the other objects. For macroscopic objects, any such process (e.g., collisions, sliding contact) also transfers some of the energy to the surrounding air by sound or heat. For molecules, collisions can also result in energy transfers through chemical processes, which increase or decrease the total amount of stored energy within a system of atoms; the change in stored energy is always balanced by a change in total kinetic energy—that of the molecules present after the process compared with the kinetic energy of the molecules present before it.

Energy can also be transferred from place to place by electric currents. Heating is another process for transferring energy. Heat transfer occurs when two objects or systems are at different temperatures. Energy moves out of higher temperature objects and into lower temperature ones, cooling the former and heating the latter. This transfer happens in three different ways—by conduction within solids, by the flow of liquid or gas (convection), and by radiation, which can travel across space. Even when a system is isolated (such as Earth in space), energy is continually being transferred into and out of it by radiation. The processes underlying convection and conduction can be understood in terms of models of the possible motions of particles in matter.

Radiation can be emitted or absorbed by matter. When matter absorbs light or infrared radiation, the energy of that radiation is transformed to thermal motion of particles in the matter, or, for shorter wavelengths (ultraviolet, X-ray), the radiation's energy is absorbed within the atoms or molecules and may possibly ionize them by knocking out an electron.

Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution within the system or between the system and its environment (e.g., water flows downhill, objects that are hotter than their surrounding environment cool down). Any object or system that can degrade with no added energy is unstable. Eventually it will change or fall apart, although in some cases it may remain in the unstable state for a long time before decaying (e.g., long-lived radioactive isotopes).

Grade-Level Endpoints for PS3.B

By the end of grade 2. Sunlight warms Earth's surface.

By the end of grade 5. Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

Light also transfers energy from place to place. For example, energy radiated from the sun is transferred to Earth by light. When this light is absorbed, it warms Earth's land, air, and water and facilitates plant growth.

Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy (e.g., moving water driving a spinning turbine which generates electric currents).

PS3.C RELATIONSHIP BETWEEN ENERGY AND FORCES

Essential Question: How are forces related to energy?

When two objects interact, each one exerts a force on the other. These forces can transfer energy between the objects. Forces between two objects at a distance are explained by force fields (gravitational, electric, or magnetic) between them. Contact forces between colliding objects can be modeled at the microscopic level as due to electromagnetic force fields between the surface particles. When two objects interacting via a force field change their relative position, the energy in the force field between them changes. For any such pair of objects the force on each object acts in the direction such that motion of that object in that direction would reduce the energy in the force field between the two objects. However, prior motion and other forces also affect the actual direction of motion.

Patterns of motion, such as a weight bobbing on a spring or a swinging pendulum, can be understood in terms of forces at each instant or in terms of transformation of energy between the motion and one or more forms of stored energy. Elastic collisions between two objects can be modeled at the macroscopic scale using conservation of energy without having to examine the detailed microscopic forces.

Grade Band Endpoints for PS3.C

By the end of grade 2. A bigger push or pull makes things go faster. Faster speeds during a collision can cause a bigger change in shape of the colliding objects.

By the end of grade 5. When objects collide, the contact forces transfer energy so as to change the objects' motions. Magnets can exert forces on other magnets or on magnetizable materials, causing energy transfer between them (e.g., leading to changes in motion) even when the objects are not touching.

PS3.D: ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE

Essential Questions: *How do food and fuel provide energy?*
If energy is conserved, why do people say it is produced or used?

In ordinary language, people speak of "producing" or "using" energy. This refers to the fact that energy in concentrated form is useful for generating electricity, moving or heating objects, and producing light, whereas diffuse energy in the environment is not readily captured for practical use. Therefore, to produce energy typically means to convert some stored energy into a desired form—for example, the stored energy of water behind a dam is released as the water flows downhill and drives a turbine generator to produce electricity, which is then delivered to users through distribution systems. Food, fuel, and batteries are especially convenient energy resources because they can be moved from place to place to provide processes that release energy where needed. A system does not destroy energy when carrying out any process. However, the process cannot occur without energy being available. The energy is also not destroyed by the end of the process. Most often some or all of it has been transferred to heat the surrounding environment; in the same sense that paper is not destroyed when it is written on, it still exists but is not readily available for further use.

Naturally occurring food and fuel contain complex carbon-based molecules, chiefly derived from plant matter that has been formed by photosynthesis. The chemical reaction of these molecules with oxygen releases energy; such reactions provide energy for most animal life and for residential, commercial, and industrial activities.

Electric power generation is based on fossil fuels (i.e., coal, oil, and natural gas), nuclear fission, or renewable resources (e.g., solar, wind, tidal, geothermal, and hydro power). Transportation today chiefly depends on fossil fuels, but the use of electric and alternative fuel (e.g., hydrogen, biofuel) vehicles is increasing. All forms of electricity generation and transportation fuels have associated economic, social, and environmental costs and benefits, both short and long term. Technological advances and regulatory decisions can change the balance of those costs and benefits.

Although energy cannot be destroyed, it can be converted to less useful forms. In designing a system for energy storage, for energy distribution, or to perform some practical task (e.g., to power an airplane), it is important to design for maximum efficiency—thereby ensuring that the largest possible fraction of the energy is used for the desired purpose rather than being transferred out of the system in unwanted ways (e.g., through friction, which eventually results in heat energy transfer to the surrounding environment). Improving efficiency reduces costs, waste materials, and many unintended environmental impacts.

Grade Band Endpoints for PS3.D

By the end of grade 2. When two objects rub against each other, this interaction is called friction. Friction between two surfaces can warm of both of them (e.g., rubbing hands together). There are ways to reduce the friction between two objects.

By the end of grade 5. The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use—for example, the stored energy of water behind a dam is released so that it flows downhill and drives a turbine generator to produce electricity. Food and fuel also release energy when they are digested or burned. When machines or animals "use" energy (e.g., to move around), most often the energy is transferred to heat the surrounding environment.

The energy released by burning fuel or digesting food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (Boundary: The fact that plants capture energy from sunlight is introduced at this grade level, but details of photosynthesis are not.)

It is important to be able to concentrate energy so that it is available for use where and when it is needed. For example, batteries are physically transportable energy storage devices, whereas electricity generated by power plants is transferred from place to place through distribution systems.

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.C: ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS

Essential Question: How do organisms obtain and use the matter and energy they need to live and grow?

Sustaining life requires substantial energy and matter inputs. The complex structural organization of organisms accommodates the capture, transformation, transport, release, and elimination of the matter and energy needed to sustain them. As matter and energy flow through different organizational levels—cells, tissues, organs, organisms, populations, communities, and ecosystems—of living systems, chemical elements are recombined in different ways to form different products. The result of these chemical reactions is that energy is transferred from one system of interacting molecules to another.

In most cases, the energy needed for life is ultimately derived from the sun through photosynthesis (although in some ecologically important cases, energy is derived from reactions involving inorganic chemicals in the absence of sunlight—e.g., chemosynthesis). Plants, algae (including phytoplankton), and other energy-fixing microorganisms use sunlight, water, and carbon dioxide to facilitate photosynthesis, which stores energy, forms plant matter, releases oxygen, and maintains plants' activities. Plants and algae—being the resource base for animals, the animals that feed on animals, and the decomposers—are energy-fixing organisms that sustain the rest of the food web.

Grade Band Endpoints for LS1.C

By the end of grade 2. All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.

By the end of grade 5. Animals and plants alike generally need to take in air and water, animals must take in food, and plants need light and minerals; anaerobic life, such as bacteria in the gut, functions without air. Food provides animals with the materials they need for body repair and growth and is digested to release the energy they need to maintain body warmth and for motion. Plants acquire their material for growth chiefly from air and water and process matter they have formed to maintain their internal conditions (e.g., at night).

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 LS2

Ecosystems: Interactions, Energy, and Dynamics

Essential Question: How and why do organisms interact with their environment and what are the effects of these interactions?

Ecosystems are complex, interactive systems that include both biological communities (biotic) and physical (abiotic) components of the environment. As with individual organisms, a hierarchal structure exists; groups of the same organisms (species) form populations, different populations interact to form communities, communities live within an ecosystem, and all of the ecosystems on Earth make up the biosphere. Organisms grow, reproduce, and perpetuate their species by obtaining necessary resources through interdependent relationships with other organisms and the physical environment. These same interactions can facilitate or restrain growth and enhance or limit the size of populations, maintaining the balance between available resources and those who consume them. These interactions can also change both biotic and abiotic characteristics of the environment. Like individual organisms, ecosystems are sustained by the continuous flow of energy, originating primarily from the sun, and the recycling of matter and nutrients within the system. Ecosystems are dynamic, experiencing shifts in population composition and abundance and changes in the physical environment over time, which ultimately affects the stability and resilience of the entire system.

LS2.A: INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS

Essential Question: How do organisms interact with the living and nonliving environments to obtain matter and energy?

Ecosystems are ever changing because of the interdependence of organisms of the same or different species and the nonliving (physical) elements of the environment. Seeking matter and energy resources to sustain life, organisms in an ecosystem interact with one another in complex feeding hierarchies of producers, consumers, and decomposers, which together represent a food web. Interactions between organisms may be predatory, competitive, or mutually beneficial. Ecosystems have carrying capacities that limit the number of organisms (within populations) they can support. Individual survival and population sizes depend on such factors as predation, disease, availability of resources, and parameters of the physical environment. Organisms rely on physical factors, such as light, temperature, water, soil, and space for shelter and reproduction. Earth's varied combinations of these factors provide the physical environments in which its ecosystems (e.g., deserts, grasslands, rain forests, and coral reefs) develop and in which the diverse species of the planet live. Within any one ecosystem, the biotic interactions between organisms (e.g., competition, predation, and various types of facilitation, such as pollination) further influence their growth, survival, and reproduction, both individually and in terms of their populations.

Grade Band Endpoints for LS2.A

By the end of grade 2. Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature. Animals depend on plants or other animals for food. They use their senses to find food and water, and they use their body parts to gather, catch, eat, and chew the food. Plants depend on air, water, minerals (in the soil), and light to grow. Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight.

By the end of grade 5. The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Either way, they are “consumers.” Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil for plants to use. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.

LS2.B: CYCLES OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS

Essential Question: How do matter and energy move through an ecosystem?

The cycling of matter and the flow of energy within ecosystems occur through interactions among different organisms and between organisms and the physical environment. All living systems need matter and energy. Matter fuels the energy-releasing chemical reactions that provide energy for life functions and provides the material for growth and repair of tissue. Energy from light is needed for plants because the chemical reaction that produces plant matter from air and water requires an energy input to occur. Animals acquire matter from food, that is, from plants or other animals. The chemical elements that make up the molecules of organisms pass through food webs and the environment and are combined and recombined in different ways. At each level in a food web, some matter provides energy for life functions, some is stored in newly made structures, and much is discarded to the surrounding environment. Only a small fraction of the matter consumed at one level is captured by the next level up. As matter cycles and energy flows through living systems and between living systems and the physical environment, matter and energy are conserved in each change.

The carbon cycle provides an example of matter cycling and energy flow in ecosystems. Photosynthesis, digestion of plant matter, respiration, and decomposition are important components of the carbon cycle, in which carbon is exchanged between the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

Grade Band Endpoints for LS2.B

By the end of grade 2. Organisms obtain the materials they need to grow and survive from the environment. Many of these materials come from organisms and are used again by other organisms.

By the end of grade 5. Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, water, and minerals from the environment and release waste matter (gas, liquid, or solid) back into the environment.

LS2.C: ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE

Essential Question: What happens to ecosystems when the environment changes?

Ecosystems are dynamic in nature; their characteristics fluctuate over time, depending on changes in the environment and in the populations of various species. Disruptions in the physical and biological components of an ecosystem—which can lead to shifts in the types and numbers of the ecosystem's organisms, to the maintenance or the extinction of species, to the migration of species into or out of the region, or to the formation of new species (speciation)—occur for a variety of natural reasons. Changes may derive from the fall of canopy trees in a forest, for example, or from cataclysmic events, such as volcanic eruptions. But many changes are induced by human activity, such as resource extraction, adverse land use patterns, pollution, introduction of nonnative species, and global climate change. Extinction of species or evolution of new species may occur in response to significant ecosystem disruptions.

Species in an environment develop behavioral and physiological patterns that facilitate their survival under the prevailing conditions, but these patterns may be maladapted when conditions change or new species are introduced. Ecosystems with a wide variety of species—that is, greater biodiversity—tend to be more resilient to change than those with few species.

Grade Band Endpoints for LS2.C

By the end of grade 2. The places where plants and animals live often change, sometimes slowly and sometimes rapidly. When animals and plants get too hot or too cold, they may die. If they cannot find enough food, water, or air, they may die.

By the end of grade 5. When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.

LS2.D: SOCIAL INTERACTIONS AND GROUP BEHAVIOR

Essential Question: How do organisms interact in groups so as to benefit individuals?

Group behaviors are found in organisms ranging from unicellular slime molds to ants to primates, including humans. Many species, with a strong drive for social affiliation, live in groups formed on the basis of genetic relatedness, physical proximity, or other recognition mechanisms (which may be species specific). Group behavior evolved because group membership can increase the chances of survival for individuals and their relatives. While some groups are stable over long periods of time, others are fluid, with members moving in and out. Groups often dissolve if their size or operation becomes counterproductive, if dominant members lose their place, or if other key members are removed from the group. Group inter-dependence is so strong that animals that usually live in groups suffer, behaviorally as well as physiologically, when reared in isolation, even if all of their physical needs are met.

Grade Band Endpoints for LS2.D

By the end of grade 2. Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.

By the end of grade 5. Groups can be collections of equal individuals, hierarchies with dominant members, small families, groups of single or mixed gender, or groups composed of individuals similar in age. Some groups are stable over long periods of time; others are fluid, with members moving in and out. Some groups assign specialized tasks to each member; in others, all members perform the same or a similar range of functions.

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.

Core Idea LS4

Biological Evolution: Unity and Diversity

Essential Questions: *How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms?*
How does biodiversity affect humans?

Biological evolution explains both the unity and the diversity of species and provides a unifying principle for the history and diversity of life on Earth. Biological evolution is supported by extensive scientific evidence ranging from the fossil record to genetic relationships among species. Researchers continue to use new and different techniques, including DNA and protein sequence analyses, to test and further their understanding of evolutionary relationships. Evolution, which is continuous and ongoing, occurs when natural selection acts on the genetic variation in a population and changes the distribution of traits in that population gradually over multiple generations. Natural selection can act more rapidly after sudden changes in conditions, which can lead to the extinction of species. Through natural selection, traits that provide an individual with an advantage to best meet environmental challenges and reproduce are the ones most likely to be passed on to the next generation. Over multiple generations, this process can lead to the emergence of new species. Evolution thus explains both the similarities of genetic material across all species and the multitude of species existing in diverse conditions on Earth—its biodiversity—which humans depend on for natural resources and other benefits to sustain themselves.

LS4.A: EVIDENCE OF COMMON ANCESTRY AND DIVERSITY

Essential Question: What evidence shows that different species are related?

Biological evolution, the process by which all living things have evolved over many generations from shared ancestors, explains both the unity and the diversity of species. The unity is illustrated by the similarities found betwen species; which can be explained by the inheritance of similar characteristics from related ancestors. The diversity of species is also consistent with common ancestry; it is explained by the branching and diversification of lineages as populations adapted, primarily through natural selection, to local circumstances.

Evidence for common ancestry can be found in the fossil record, from comparative anatomy and embryology, from the similarities of cellular processes and structures, and from comparisons of DNA sequences between species. The understanding of evolutionary relationships has recently been greatly accelerated by using new molecular tools to study developmental biology, with researchers dissecting the genetic basis for some of the changes seen in the fossil record, as well as those that can be inferred to link living species (e.g., the armadillo) to their ancestors (e.g., glyptodonts, a kind of extinct gigantic armadillo).

Grade Band Endpoints for LS4.A

By the end of grade 2. Some kinds of plants and animals that once lived on Earth (e.g., dinosaurs) are no longer found anywhere, although others now living (e.g., lizards) resemble them in some ways.

By the end of grade 5. Fossils provide evidence about the types of organisms (both visible and microscopic) that lived long ago and also about the nature of their environments. Fossils can be compared with one another and to living organisms according to their similarities and differences.

LS4.B: NATURAL SELECTION

Essential Question: How does genetic variation among organisms affect survival and reproduction?

Genetic variation in a species results in individuals with a range of traits. In any particular environment individuals with particular traits may be more likely than others to survive and produce offspring. This process is called natural selection and may lead to the predominance of certain inherited traits in a population and the suppression of others. Natural selection occurs only if there is variation in the genetic information within a population that is expressed in traits that lead to differences in survival and reproductive ability among individuals under specific environmental conditions. If the trait differences do not affect reproductive success, then natural selection will not favor one trait over others.

Grade Band Endpoints for LS4.B

By the end of grade 2. [Intentionally left blank.]

By the end of grade 5. Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

LS4.C: ADAPTATION

Essential Question: How does the environment influence populations of organisms over multiple generations?

When an environment changes, there can be subsequent shifts in its supply of resources or in the physical and biological challenges it imposes. Some individuals in a population may have morphological, physiological, or behavioral traits that provide a reproductive advantage in the face of the shifts in the environment. Natural selection provides a mechanism for species to adapt to changes in their environment. The resulting selective pressures influence the survival and reproduction of organisms over many generations and can change the distribution of traits in the population. This process is called adaptation. Adaptation can lead to organisms that are better suited for their environment because individuals with the traits adaptive to the environmental change pass those traits on to their offspring, whereas individuals with traits that are less adaptive produce fewer or no offspring. Over time, adaptation can lead to the formation of new species. In some cases, however, traits that are adaptive to the changed environment do not exist in the population and the species becomes extinct. Adaptive changes due to natural selection, as well as the net result of speciation minus extinction, have strongly contributed to the planet's biodiversity.

Adaption by natural selection is ongoing. For example it is seen in the emergence of antibiotic-resistant bacteria. Organisms like bacteria, in which multiple generations occur over shorter time spans, evolve more rapidly than those for which each generation takes multiple years.

Grade Band Endpoints for LS4.C

By the end of grade 2. Living things can survive only where their needs are met. If some places are too hot or too cold or have too little water or food, plants and animals may not be able to live there.

By the end of grade 5. Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

LS4.D: BIODIVERSITY AND HUMANS

Essential Question: What is biodiversity, how do humans affect it, and how does it affect humans?

Human beings are part of and depend on the natural world. Biodiversity—the multiplicity of genes, species, and ecosystems—provides humans with renewable resources, such as food, medicines, and clean water. Humans also benefit from "ecosystem services," such as climate stabilization, decomposition of wastes, and pollination that are provided by healthy (i.e., diverse and resilient) ecosystems. The resources of biological communities can be used within sustainable limits, but in many cases humans affect these ecosystems in ways—including habitat destruction, pollution of air and water, overexploitation of resources, introduction of invasive species, and climate change—that prevent the sustainable use of resources and lead to ecosystem degradation, species extinction, and the loss of valuable ecosystem services.

Grade Band Endpoints for LS4.D

By the end of grade 2. There are many different kinds of living things in any area, and they exist in different places on land and in water.

By the end of grade 5. Scientists have identified and classified many plants and animals. Populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. Humans, like all other organisms, obtain living and nonliving resources from their environments.

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 nonstellar 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.

ESS1.C: THE HISTORY OF PLANET EARTH

Essential Question: How do people reconstruct and date events in Earth's planetary history?

Earth scientists use the structure, sequence, and properties of rocks, sediments, and fossils, as well as the locations of current and past ocean basins, lakes, and rivers, to reconstruct events in Earth's planetary history. For example, rock layers show the sequence of geological events, and the presence and amount of radioactive elements in rocks make it possible to determine their ages.

Analyses of rock formations and the fossil record are used to establish relative ages. In an undisturbed column of rock, the youngest rocks are at the top, and the oldest are at the bottom. Rock layers have sometimes been rearranged by tectonic forces; rearrangements can be seen or inferred, such as from inverted sequences of fossil types. Core samples obtained from drilling reveal that the continents' rocks (some as old as 4 billion years or more) are much older than rocks on the ocean floor (less than 200 million years), where tectonic processes continually generate new rocks and destroy old ones. The rock record reveals that events on Earth can be catastrophic, occurring over hours to years, or gradual, occurring over thousands to millions of years. Records of fossils and other rocks also show past periods of massive extinctions and extensive volcanic activity. Although active geological processes, such as plate tectonics (link to ESS2.B) and erosion have destroyed or altered most of the very early rock record on Earth, some other objects in the solar system, such as asteroids and meteorites, have changed little over billions of years. Studying these objects can help scientists deduce the solar system's age and history, including the formation of planet Earth. Study of other planets and their moons, many of which exhibit such features as volcanism and meteor impacts similar to those found on Earth, also help illuminate aspects of Earth's history and changes.

The geological time scale organizes Earth's history into the increasingly long time intervals of eras, periods, and epochs. Major historical events include the formation of mountain chains and ocean basins, volcanic activity, the evolution and extinction of living organisms, periods of massive glaciation, and development of watersheds and rivers. Because many individual plant and animal species existed during known time periods (e.g., dinosaurs), the location of certain types of fossils in the rock record can reveal the age of the rocks and help geologists decipher the history of landforms.

Grade Band Endpoints for ESS1.C

By the end of grade 2. Some events on Earth occur in cycles, like day and night, and others have a beginning and an end, like a volcanic eruption. Some events, like an earthquake, happen very quickly; others, such as the formation of the Grand Canyon, occur very slowly, over a time period much longer than one can observe.

By the end of grade 5. Earth has changed over time. Understanding how landforms develop, are weathered (broken down into smaller pieces), and erode (get transported elsewhere) can help infer the history of the current landscape. Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. Patterns of tree rings and ice cores from glaciers can help reconstruct Earth's recent climate history.

Core Idea ESS2

Earth's Systems

Essential Question: How and why is Earth constantly changing?

Earth's surface is a complex and dynamic set of interconnected systems—principally the geosphere, hydrosphere, atmosphere, and biosphere—that interact over a wide range of temporal and spatial scales. All of Earth's processes are the result of energy flowing and matter cycling within and among these systems. For example, the motion of tectonic plates is part of the cycles of convection in Earth's mantle, driven by outflowing heat and the downward pull of gravity, which result in the formation and changes of many features of Earth's land and undersea surface. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, clouds, ice, land, and life forms. Earth's biosphere has changed the makeup of the geosphere, hydrosphere, and atmosphere over geological time; conversely, geological events and conditions have influenced the evolution of life on the planet. Water is essential to the dynamics of most earth systems, and it plays a significant role in shaping Earth's landscape.

ESS2.A: EARTH MATERIALS AND SYSTEMS

Essential Question: How do Earth's major systems interact?

Earth is a complex system of interacting subsystems: the geosphere, hydrosphere, atmosphere, and biosphere. The geosphere includes a hot and mostly metallic inner core; a mantle of hot, soft, solid rock; and a crust of rock, soil, and sediments. The atmosphere is the envelope of gas surrounding the planet. The hydrosphere is the ice, water vapor, and liquid water in the atmosphere, ocean, lakes, streams, soils, and groundwater. The presence of living organisms of any type defines the biosphere; life can be found in many parts of the geosphere, hydrosphere, and atmosphere. Humans are of course part of the biosphere, and human activities have important impacts on all of Earth's systems.

All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. This energy originates from the sun and from Earth's interior. Transfers of energy and the movements of matter can cause chemical and physical changes among Earth's materials and living organisms.

Solid rocks, for example, can be formed by the cooling of molten rock, the accumulation and consolidation of sediments, or the alteration of older rocks by heat, pressure, and fluids. These processes occur under different circumstances and produce different types of rock. Physical and chemical interactions among rocks, sediments, water, air, and plants and animals produce soil. In the carbon, water, and nitrogen cycles, materials cycle between living and nonliving forms and among the atmosphere, soil, rocks, and ocean.

Weather and climate are driven by interactions of the geosphere, hydrosphere, and atmosphere, with inputs of energy from the sun. The tectonic and volcanic processes that create and build mountains and plateaus, for example, as well as the weathering and erosion processes that break down these structures and transport the products, all involve interactions among the geosphere, hydrosphere, and atmosphere. The resulting landforms and the habitats they provide affect the biosphere, which in turn modifies these habitats and affects the atmosphere, particularly through imbalances between the carbon capture and oxygen release that occur in photosynthesis, and the carbon release and oxygen capture that occur in respiration and in the burning of fossil fuels to support human activities.

Earth exchanges mass and energy with the rest of the solar system. It gains or loses energy through incoming solar radiation, thermal radiation to space, and gravitational forces exerted by the sun, moon, and planets. Earth gains mass from the impacts of meteoroids and comets and loses mass from the escape of gases into space.

Earth's systems are dynamic; they interact over a wide range of temporal and spatial scales and continually react to changing influences, including human activities. Components of Earth's systems may appear stable, change slowly over long periods of time, or change abruptly, with significant consequences for living organisms. Changes in part of one system can cause further changes to that system or to other systems, often in surprising and complex ways.

Grade Band Endpoints for ESS2.A

By the end of grade 2. Wind and water can change the shape of the land. The resulting landforms, together with the materials on the land, provide homes for living things.

By the end of grade 5. Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. Rainfall helps shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. Human activities affect Earth's systems and their interactions at its surface.

ESS2.B: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS

Essential Question: Why do the continents move, and what causes earthquakes and volcanoes?

Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. This theory is supported by multiple evidence streams—for example, the consistent patterns of earthquake locations, evidence of ocean floor spreading over time given by tracking magnetic patterns in undersea rocks and coordinating them with changes to Earth's magnetic axis data, the warping of the land under loads (such as lakes and ice sheets), which show that the solid mantle's rocks can bend and even flow.

The lighter and less dense continents are embedded in heavier and denser upper-mantle rocks, and together they make up the moving tectonic plates of the lithosphere (Earth's solid outer layer, i.e., the crust and upper mantle). Tectonic plates are the top parts of giant convection cells that bring matter from the hot inner mantle up to the cool surface. These movements are driven by the release of energy (from radioactive decay of unstable isotopes within Earth's interior) and by the cooling and gravitational downward motion of the dense material of the plates after subduction (one plate being drawn under another). The plates move across Earth's surface, carrying the continents, creating and destroying ocean basins, producing earthquakes and volcanoes, and forming mountain ranges and plateaus.

Most continental and ocean floor features are the result of geological activity and earthquakes along plate boundaries. The exact patterns depend on whether

the plates are being pushed together to create mountains or deep ocean trenches, being pulled apart to form new ocean floor at mid-ocean ridges, or sliding past each other along surface faults. Most distributions of rocks within Earth's crust, including minerals, fossil fuels, and energy resources, are a direct result of the history of plate motions and collisions and the corresponding changes in the configurations of the continents and ocean basins.

This history is still being written. Continents are continually being shaped and reshaped by competing constructive and destructive geological processes. North America, for example, has gradually grown in size over the past 4 billion years through a complex set of interactions with other continents, including the addition of many new crustal segments.

Grade Band Endpoints for ESS2.B

By the end of grade 2. Rocks, soils, and sand are present in most areas where plants and animals live. There may also be rivers, streams, lakes, and ponds. Maps show where things are located. One can map the shapes and kinds of land and water in any area.

By the end of grade 5. The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features where people live and in other areas of Earth.

ESS2.C: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES

Essential Question: How do the properties and movements of water shape Earth's surface and affect its systems?

Earth is often called the water planet because of the abundance of liquid water on its surface and because water's unique combination of physical and chemical properties is central to Earth's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy as it changes state; to transmit sunlight; to expand upon freezing; to dissolve and transport many materials; and to lower the viscosities and freezing points of the material when mixed with fluid rocks in the mantle. Each of these properties plays a role in how water affects other Earth systems (e.g., ice expansion contributes to rock erosion, ocean thermal capacity contributes to moderating temperature variations).

Water is found almost everywhere on Earth, from high in the atmosphere (as water vapor and ice crystals) to low in the atmosphere (precipitation, droplets in clouds) to mountain snowcaps and glaciers (solid) to running liquid water on the land, ocean, and underground. Energy from the sun and the force of gravity drive the continual cycling of water among these reservoirs. Sunlight causes evaporation and propels oceanic and atmospheric circulation, which transports water around the globe. Gravity causes precipitation to fall from clouds and water to flow downward on the land through watersheds.

About 97 percent of Earth's water is in the ocean, and most fresh water is contained in glaciers or underground aquifers; only a tiny fraction of Earth's water is found in streams, lakes, and rivers. The relative availability of water is a major factor in distinguishing habitats for different living organisms.

Water participates both in the dissolution and formation of Earth's materials. The downward flow of water, both in liquid and solid form, shapes landscapes through the erosion, transport, and deposition of sediment. Shoreline waves in the ocean and lakes are powerful agents of erosion. Over millions of years, coastlines have moved back and forth over continents by hundreds of kilometers, largely due to the rise and fall of sea level as the climate changed (e.g., ice ages).

Grade Band Endpoints for ESS2.C

By the end of grade 2. Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. It carries soil and rocks from one place to another and determines the variety of life forms that can live in a particular location.

By the end of grade 5. Water is found almost everywhere on Earth: as vapor; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as groundwater beneath the surface. The downhill movement of water as it flows to the ocean shapes the appearance of the land. Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

ESS2.D: WEATHER AND CLIMATE

Essential Question: What regulates weather and climate?

Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over 1 year or many years, and, because it depends on latitude and geography, it varies from place to place. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries, and beyond—for climate.

The ocean exerts a major influence on weather and climate. It absorbs and stores large amounts of energy from the sun and releases it very slowly; in that way, the ocean moderates and stabilizes global climates. Energy is redistributed globally through ocean currents (e.g., the Gulf Stream) and also through atmospheric circulation (winds). Sunlight heats Earth's surface, which in turn heats the atmosphere. The resulting temperature patterns, together with Earth's rotation and the configuration of continents and oceans, control the large-scale patterns of atmospheric circulation. Winds gain energy and water vapor content as they cross hot ocean regions, which can lead to tropical storms.

The "greenhouse effect" keeps Earth's surface warmer than it would be otherwise. To maintain any average temperature over time, energy inputs from the sun and from radioactive decay in Earth's interior must be balanced by energy loss due to radiation from the upper atmosphere. However, what determines the temperature at which this balance occurs is a complex set of absorption, reflection, transmission, and redistribution processes in the atmosphere and oceans that determine how long energy stays trapped in these systems before being radiated away. Certain gases in the atmosphere (water vapor, carbon dioxide, methane, and nitrous oxides), which absorb and retain energy that radiates from Earth's surface, essentially insulate the planet. Without this phenomenon, Earth's surface would be too cold to be habitable. However, changes in the atmosphere, such as increases in carbon dioxide, can make regions of Earth too hot to be habitable by many species.

Climate changes, which are defined as significant and persistent changes in an area's average or extreme weather conditions, can occur if any of Earth's systems change (e.g., composition of the atmosphere, reflectivity of Earth's surface). Positive feedback loops can amplify the impacts of these effects and trigger relatively abrupt changes in the climate system; negative feedback loops tend to maintain stable climate conditions.

Some climate changes in Earth's history were rapid shifts (caused by events, such as volcanic eruptions and meteoric impacts, that suddenly put a large amount of particulate matter into the atmosphere or by abrupt changes in ocean currents); other climate changes were gradual and longer term—due, for example, to solar output variations, shifts in the tilt of Earth's axis, or atmospheric change due to the rise of plants and other life forms that modified the atmosphere via photosynthesis. Scientists can infer these changes from geological evidence.

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Grade Band Endpoints for ESS2.D

By the end of grade 2. Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.

By the end of grade 5. Weather is the minute-by-minute to day-by-day variation of the atmosphere's condition on a local scale. Scientists record the patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. Climate describes the ranges of an area's typical weather conditions and the extent to which those conditions vary over years to centuries.

ESS2.E: BIOGEOLOGY

Essential Question: How do living organisms alter Earth's processes and structures?

Evolution, including the emergence and extinction of species, is a natural and ongoing process that is shaped by Earth's dynamic processes. The properties and conditions of Earth and its atmosphere affect the environments and conditions within which life emerged and evolved—for example, the range of frequencies of light that penetrate the atmosphere to Earth's surface. Organisms continually evolve to new and often more complex forms as they adapt to new environments. The evolution and proliferation of living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Plants, algae, and microorganisms produced most of the oxygen (i.e., the O_2) in the atmosphere through photosynthesis, and they enabled the formation of fossil fuels and types of sedimentary rocks. Microbes also changed the chemistry of Earth's surface, and they continue to play a critical role in nutrient cycling (e.g., of nitrogen) in most ecosystems.

Organisms ranging from bacteria to human beings are a major driver of the global carbon cycle, and they influence global climate by modifying the chemical makeup of the atmosphere. Greenhouse gases in particular are continually movedthrough the reservoirs represented by the ocean, land, life, and atmosphere. The abundance of carbon in the atmosphere is reduced through the ocean floor accumulation of marine sediments and the accumulation of plant biomass; atmospheric carbon is increased through such processes as deforestation and the burning of fossil fuels.

As Earth changes, life on Earth adapts and evolves to those changes, so just as life influences other Earth systems, other Earth systems influence life. Life and the planet's nonliving systems can be said to co-evolve.

Grade Band Endpoints for ESS2.E

By the end of grade 2. Plants and animals (including humans) depend on the land, water, and air to live and grow. They in turn can change their environment (e.g., the shape of land, the flow of water).

By the end of grade 5. Living things affect the physical characteristics of their regions (e.g., plants' roots hold soil in place, beaver shelters and human-built dams alter the flow of water, plants' respiration affects the air). Many types of rocks and minerals are formed from the remains of organisms or are altered by their activities.

Core Idea ESS3

Earth and Human Activity

Essential Question: How do Earth's surface processes and human activities affect each other?

Earth's surface processes affect and are affected by human activities. Humans depend on all of the planet's systems for a variety of resources, some of which are renewable or replaceable and some of which are not. Natural hazards and other geological events can significantly alter human populations and activities. Human activities, in turn, can contribute to the frequency and intensity of some natural hazards. Indeed, humans have become one of the most significant agents of change in Earth's surface systems. In particular, it has been shown that climate change—which could have large consequences for all of Earth's surface systems, including the biosphere—is driven not only by natural effects but also by human activities. Sustaining the biosphere will require detailed knowledge and modeling of the factors that affect climate, coupled with the responsible management of natural resources.

ESS3.A: NATURAL RESOURCES

Essential Question: How do humans depend on Earth's resources?

Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources, including air, water, soil, minerals, metals, energy, plants, and animals. Some of these resources are renewable over human lifetimes, and some are nonrenewable (mineral resources and fossil fuels) or irreplaceable if lost (extinct species).

Materials important to modern technological societies are not uniformly distributed across the planet (e.g., oil in the Middle East, gold in California). Most elements exist in Earth's crust at concentrations too low to be extracted, but in some locations—where geological processes have concentrated them—extraction is economically viable. Historically, humans have populated regions that are climatically, hydrologically, and geologically advantageous for fresh water availability, food production via agriculture, commerce, and other aspects of civilization. Resource availability affects geopolitical relationships and can limit development. As the global human population increases and people's demands for better living conditions increase, resources considered readily available in the past, such as land for agriculture or drinkable water, are becoming scarcer and more valued.

All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs and risks, as well as benefits. New technologies and regulations can change the balance of these factors—for example, scientific modeling of the long-term environmental impacts of resource use can help identify potential problems and suggest desirable changes in the patterns of use. Much energy production today comes from nonrenewable sources, such as coal and oil. However, advances in related science and technology are reducing the cost of energy from renewable resources, such as sunlight, and some regulations are favoring their use. As a result, future energy supplies are likely to come from a much wider range of sources.

Grade Band Endpoints for ESS3.A

By the end of grade 2. Living things need water, air, and resources from the land, and they try to live in places that have the things they need. Humans use natural resources for everything they do: for example, they use soil and water to grow food, wood to burn to provide heat or to build shelters, and materials such as iron or copper extracted from Earth to make cooking pans.

By the end of grade 5. All materials, energy, and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.

ESS3.B: NATURAL HAZARDS

Essential Question: How do natural hazards affect individuals and societies?

Natural processes can cause sudden or gradual changes to Earth's systems, some of which may adversely affect humans. Through observations and knowledge of historical events, people know where certain of these hazards—such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion—are likely to occur. Understanding these kinds of hazards helps us prepare for and respond to them.

While humans cannot eliminate natural hazards, they can take steps to reduce their impacts. For example, loss of life and economic costs have been greatly reduced by improving construction, developing warning systems, identifying and avoiding high-risk locations, and increasing community preparedness and response capability.

Some natural hazards are preceded by geological activities that allow for reliable predictions; others occur suddenly, with no notice, and are not yet predictable. By tracking the upward movement of magma, for example, volcanic eruptions can often be predicted with enough advance warning to allow neighboring regions to be evacuated. Earthquakes, in contrast, occur suddenly; the specific time, day, or year cannot be predicted. However, the history of earthquakes in a region and the mapping of fault lines can help forecast the likelihood of future events. Finally, satellite monitoring of weather patterns, along with measurements from land, sea, and air, usually can identify developing severe weather and lead to its reliable forecast.

Natural hazards and other geological events have shaped the course of human history, sometimes significantly altering the size of human populations or driving human migrations. Natural hazards can be local, regional, or global in origin, and even local events can have distant impacts because of the interconnectedness of human societies and Earth's systems. Human activities can contribute to the frequency and intensity of some natural hazards (e.g., flooding, forest fires), and risks from natural hazards increase as populations—and population densities—increase in vulnerable locations.

Grade Band Endpoints for ESS3.B

By the end of grade 2. Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that communities can prepare for and respond to these events.

By the end of grade 5. A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

ESS3.C: HUMAN IMPACTS ON EARTH SYSTEMS

Essential Question: How do humans change the planet?

Recorded history, as well as chemical and geological evidence, indicates that human activities in agriculture, industry, and everyday life have had major impacts on the land, rivers, ocean, and air. Humans affect the quality, availability, and distribution of Earth's water through the modification of streams, lakes, and groundwater. Large areas of land, including such delicate ecosystems as wetlands, forests, and grasslands, are being transformed by human agriculture, mining, and the expansion of settlements and roads. Human activities now cause land erosion and soil movement annually that exceed all natural processes. Air and water pollution caused by human activities affect the condition of the atmosphere and of rivers and lakes, with damaging effects on other species and on human health. The activities of humans have significantly altered the biosphere, changing or destroying natural habitats and causing the extinction of many living species. These changes also affect the viability of agriculture or fisheries to support human populations. Land use patterns for agriculture and ocean use patterns for fishing are affected not only by changes in population and needs but also by changes in climate or local conditions (such as desertification due to overuse or depletion of fish populations by overextraction).

Thus humans have become one of the most significant agents of change in the near-surface Earth system. And because all of Earth's subsystems are interconnected, changes in one system can produce unforeseen changes in others.

The activities and advanced technologies that have built and maintained human civilizations clearly have large consequences for the sustainability of these civilizations and the ecosystems with which they interact. As the human population grows and per-capita consumption of natural resources increases to provide a greater percentage of people with more developed lifestyles and greater longevity, so do the human impacts on the planet.

Some negative effects of human activities are reversible with informed and responsible management. For example, communities are doing many things to help protect Earth's resources and environments. They are treating sewage, reducing the amount of materials they use, and reusing and recycling materials. Regulations regarding water and air pollution have greatly reduced acid rain and stream pollution, and international treaties on the use of certain refrigerant gases have halted the growth of the annual ozone hole over Antarctica. Regulation of fishing and the development of marine preserves can help restore and maintain fish populations. In addition, the development of alternative energy sources can reduce the environmental impacts otherwise caused by the use of fossil fuels.

The sustainability of human societies and of the biodiversity that supports them requires responsible management of natural resources not only to reduce existing adverse impacts but also to prevent such impacts to the extent possible. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

Grade Band Endpoints for ESS3.C

By the end of grade 2. Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things—for example, by reducing trash through reuse and recycling.

By the end of grade 5. Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. For example, they are treating sewage, reducing the amounts of materials they use, and regulating sources of pollution such as emissions from factories and power plants or the runoff from agricultural activities.

ESS3.D: GLOBAL CLIMATE CHANGE

Essential Question: How do people model and predict the effects of human activities on Earth's climate?

Global climate change, shown to be driven by both natural phenomena and by human activities, could have large consequences for all of Earth's surface systems, including the biosphere (see ESS3.C for a general discussion of climate). Humans are now so numerous and resource dependent that their activities affect every part of the environment, from outer space and the stratosphere to the deepest ocean.

However, by using science-based predictive models, humans can anticipate long-term change more effectively than ever before and plan accordingly.

Global changes usually happen too slowly for individuals to recognize, but accumulated human knowledge, together with further scientific research, can help people learn more about these challenges and guide their responses. For example, there are historical records of weather conditions and of the times when plants bloom, animals give birth or migrate, and lakes and rivers freeze and thaw. And scientists can deduce long-past climate conditions from such sources as fossils, pollen grains found in sediments, and isotope ratios in samples of ancient materials.

Scientists build mathematical climate models that simulate the underlying physics and chemistry of the many Earth systems and their complex interactions with each other. These computational models summarize the existing evidence, are tested for their ability to match past patterns, and are then used (together with other kinds of computer models) to forecast how the future may be affected by human activities. The impacts of climate change are uneven and may affect some regions, species, or human populations more severely than others.

Climate models are important tools for predicting, for example, when and where new water supplies will be needed, when and which natural resources will become scarce, how weather patterns may change and with what consequences, whether proposed technological concepts for controlling greenhouse gases will work, and how soon people will have to leave low-lying coastal areas if sea levels continue to rise. Meanwhile, important discoveries are being made—for example, about how the biosphere is responding to the climate changes that have already occurred, how the atmosphere is responding to changes in anthropogenic greenhouse gas emissions, and how greenhouse gases move between the ocean and the atmosphere over long periods. Such information, from models and other scientific and engineering efforts, will continue to be essential to planning for humanity's—and the global climate's—future.

It is important to note that although forecasting the consequences of environmental change is crucial to society, it involves so many complex phenomena and uncertainties that predictions, particularly long-term predictions, always have uncertainties. These arise not only from uncertainties in the underlying science but also from uncertainties about behavioral, economic, and political factors that affect human activity and changes in activity in response to recognition of the problem. However, it is clear not only that human activities play a major role in climate change but also that impacts of climate change—for example, increased frequency of severe storms due to ocean warming—have begun to influence human activities. The prospect of future impacts of climate change due to further increases in atmospheric carbon is prompting consideration of how to avoid or restrict such increases.

Grade Band Endpoints for ESS3.D

By the end of grade 2. [Intentionally left blank.]

By the end of grade 5. If Earth's global mean temperature continues to rise, the lives of humans and other organisms will be affected in many different ways.

Engineering, Technology and Application of Science K-5 Progression

Engineering, Technology, and Applications of Science	K	1	2	3	4	5
ETS1: Engineering Design						
ETS1A Defining and Delimiting Engineering Problems	X				X	
ETS1B Developing Possible Solutions	X		X		X	
ETS1C Optimizing the Design Solution			X		X	
ETS2: Links Among Engineering, Technology, Science and						
ETS2.A Interdependence of Science, Engineering and Technology						
ETS2.B Influence of Engineering, Technology, and Science on Society and the Natural World						

Core Idea ETS1

Engineering Design

Essential Question: How do engineers solve problems?

The design process—engineers' basic approach to problem solving—involves many different practices. They include problem definition, model development and use, investigation, analysis and interpretation of data, application of mathematics and computational thinking, and determination of solutions. These engineering practices incorporate specialized knowledge about criteria and constraints, modeling and analysis, and optimization and trade-offs.

ETS1.A: DEFINING AND DELIMITING AN ENGINEERING PROBLEM

Essential Questions: *What is a design for?*
What are the criteria and constraints of a successful solution?

The engineering design process begins with the identification of a problem to solve and the specification of clear goals, or criteria, that the final product or system must meet. Criteria, which typically reflect the needs of the expected end-user of a technology or process, address such things as how the product or system will function (what job it will perform and how), its durability, and its cost. Criteria should be quantifiable whenever possible and stated so that one can tell if a given design meets them.

Engineers must contend with a variety of limitations, or constraints, when they engage in design. Constraints, which frame the salient conditions under which the problem must be solved, may be physical, economic, legal, political, social, ethical, aesthetic, or related to time and place. In terms of quantitative measurements, constraints may include limits on cost, size, weight, or performance, for example. And although constraints place restrictions on a design, not all of them are permanent or absolute.

Grade Band End Points for ETS1.A

By the end of grade 2. A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.

By the end of grade 5. Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: DEVELOPING POSSIBLE SOLUTIONS

Essential Question: What is the process for developing potential design solutions?

The creative process of developing a new design to solve a problem is a central element of engineering. This process may begin with a relatively open-ended phase during which new ideas are generated both by individuals and by group processes such as brainstorming. Before long, the process must move to the specification of solutions that meet the criteria and constraints at hand. Initial ideas may be communicated through informal sketches or diagrams, although they typically become more formalized through models. The ability to build and use physical, graphical, and mathematical models is an essential part of translating a design idea into a finished product, such as a machine, building, or any other working system. Because each area of engineering focuses on particular types of systems (e.g., mechanical, electrical, biotechnological), engineers become expert in the elements that such systems need. But whatever their fields, all engineers use models to help develop and communicate solutions to design problems.

Models allow the designer to better understand the features of a design problem, visualize elements of a possible solution, predict a design's performance, and guide the development of feasible solutions (or, if possible, the optimal solution). A physical model can be manipulated and tested for parameters of interest, such as strength, flexibility, heat conduction, fit with other components, and durability. Scale models and prototypes are particular types of physical models. Graphical models, such as sketches and drawings, permit engineers to easily share and discuss design ideas and to rapidly revise their thinking based on input from others.

Mathematical models allow engineers to estimate the effects of a change in one feature of the design (e.g., material composition, ambient temperature) on other features, or on performance as a whole, before the designed product is actually built. Mathematical models are often embedded in computer-based simulations. Computer-aided design (CAD) and computer-aided manufacturing (CAM) are modeling tools commonly used in engineering.

Data from models and experiments can be analyzed to make decisions about modifying a design. The analysis may reveal performance information, such as which criteria a design meets, or predict how well the overall designed system or system component will behave under certain conditions. If analysis reveals that the predicted performance does not align with desired criteria, the design can be adjusted.

Grade Band Endpoints for ETS1.B

By the end of grade 2. Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. To design something complicated, one may need to break the problem into parts and attend to each part separately but must then bring the parts together to test the overall plan.

By the end of grade 5. Research on a problem should be carried out—for example, through Internet searches, market research, or field observations—before beginning to design a solution. An often productive way to generate ideas is for people to work together to brainstorm, test, and refine possible solutions. Testing a solution involves investigating how well it performs under a range of likely conditions. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

There are many types of models, ranging from simple physical models to computer models. They can be used to investigate how a design might work, communicate the design to others, and compare different designs.

ETS1.C: OPTIMIZING THE DESIGN SOLUTION

Essential Question: How can the various proposed design solutions be compared and improved?

Multiple solutions to an engineering design problem are always possible because there is more than one way to meet the criteria and satisfy the constraints. But the aim of engineering is not simply to design a solution to a problem but to design the best solution. Determining what constitutes “best,” however, requires value judgments, given that one person’s view of the optimal solution may differ from another’s.

Optimization often requires making trade-offs among competing criteria. For example, as one criterion (such as lighter weight) is enhanced, another (such as unit cost) might be sacrificed (i.e., cost may be increased due to the higher cost of lightweight materials). In effect, one criterion is devalued or traded off for another that is deemed more important. When multiple possible design options are under consideration, with each optimized for different criteria, engineers may use a trade-off matrix to compare the overall advantages and disadvantages of the different proposed solutions.

The decision as to which criteria are critical and which ones can be traded off is a judgment based on the situation and the perceived needs of the end-user of the product or system. Because many factors—including environmental or health impacts, available technologies, and the expectations of users—change over time and vary from place to place, a design solution that is considered optimal at one time and place may appear far from optimal at other times and places. Thus different designs, each of them optimized for different conditions, are often needed.

Grade Band Endpoints for ETS1.C

By the end of grade 2. Because there is always more than one possible solution to a problem, it is useful to compare designs, test them, and discuss their strengths and weaknesses.

By the end of grade 5. Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

A Closer Look at the Scope and Sequence
Kindergarten 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.

K-ESS2-1 K = grade level
ESS2 = Core Idea
1 = the number within the core idea (so this is the first performance expectation in the core idea ESS2)

K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time.	
Science and Engineering Practice • **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 • **ESS2.D: Weather and Climate -** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.	what they will understand
Crosscutting Concept • **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

KINDERGARTEN OVERVIEW

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

PS = Physical Science

LS = Life Science

ESS = Earth Space Science

ETS = Engineering, Technology, and Application of Science

BLUE VALLEY DISTRICT CURRICULUM

Science | Grade K

ORGANIZING THEME/TOPIC	FOCUS STANDARDS AND SKILLS
Weather and Climate **Bring Science Alive!** Unit 3: Weather Lessons 1 - 2 Suggested Time Frame: 25 days	**K-ESS2-1.** Use and share observations of local weather conditions to describe patterns over time. Science and Engineering Practice • **Analyzing and Interpreting Data** – Use observation to describe patterns in the natural world in order to answer scientific questions. Disciplinary Core Idea • **ESS2.D: Weather and Climate -** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. Crosscutting Concept • **Patterns** - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.
Sunlight **Bring Science Alive!** Unit 3: Weather Lessons 3 - 4 Suggested Time Frame: 17 days	**K-PS3-1.** Make observations to determine the effect of sunlight on Earth's surface. **K-PS3-2.** Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area. Science and Engineering Practices • **Planning and Carrying Out Investigations** – Make observations to collect data that can be used to make comparisons. • **Constructing Explanations and Designing Solutions –** Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem. Disciplinary Core Idea • **PS3.B: Conservation of Energy and Energy Transfer -** Sunlight warms Earth's surface. Crosscutting Concept • **Cause and Effect** – Events have causes that generate observable patterns.

Severe Weather **Bring Science Alive!** Unit 3: Weather Lessons 5 - 6 Suggested Time Frame: 19 days	**K-ESS3-2. Ask questions to obtain information** about the purpose of **weather forecasting** to prepare for, and respond to, severe weather. **Science and Engineering Practices** • **Asking Questions and Defining Problems** – Ask questions based on observations to find more information about the designed world. • **Obtaining, Evaluating, and Communicating Information** - Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world. **Disciplinary Core Ideas** • **ESS3.B: Natural Hazards -** Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. • **ETS1.A: Defining and Delimiting an Engineering Problem –** Asking questions, making observations, and gathering information are helpful in thinking about problems. **Crosscutting Concepts** • **Cause and Effect –** Events have causes that generate observable patterns.
Plant and Animal Needs **Bring Science Alive!** Unit 1: Plants and Animals Lessons 1-3 Suggested Time Frame: 29 days	**K-LS1-1. Use observations to describe patterns of** what plants and animals (including humans) need to survive. **Science and Engineering Practice** • **Analyzing and Interpreting Data** - Use observations to describe patterns in the natural world in order to answer scientific questions. **Disciplinary Core Idea** • **LS1.C: Organization for Matter and Energy Flow in Organisms -** All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. **Crosscutting Concepts** • **Patterns** – Patterns in the natural and human designed world can be observed and used as evidence.
Relationships: Plants, Animals and Places **Bring Science Alive!** Unit 1: Plants and Animals Lesson 4 Suggested Time Frame: 9 days	**K-ESS3-1. Use a model to represent the relationship between the needs** of different plants and animals (including humans) **and the places** they live. **Science and Engineering Practice** • **Developing and Using Models** – Use a model to represent relationships in the natural world. **Disciplinary Core Idea** • **ESS3.A: Natural Resources -** Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. **Crosscutting Concept** • **System and System Models** – Systems in the natural and designed world have parts that work together.

Changing the Environment **Bring Science Alive!** Unit 1: Plants and Animals Lessons 5 – 7 Suggested Time Frame: 34 days	**K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment** to meet their needs**.** Science and Engineering Practice • **Engaging in Argument from Evidence** – Construct an argument with evidence to support a claim. Disciplinary Core Idea • **ESS2.E: Biogeology** - Plants and Animals can change their environment. Crosscutting Concept • **Systems and System Models** – Systems in the natural and designed world have parts that work together. **K-ESS3-3. Communicate solutions t**hat will reduce **the impact of** humans on the land, water, air, and/or other living things in the local environment. Science and Engineering Practice • **Obtaining, Evaluating, and Communicating Information** – Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas. Disciplinary Core Idea • **ESS3.C: Human Impacts on Earth Systems** - Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. • **ETS1.B: Developing Possible Solutions –** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. Crosscutting Concept • **Cause and Effect** – Events have causes that generate observable patterns.

Push and Pull **Bring Science Alive!** Unit 2: Pushes and Pulls Lessons 1 - 5 Suggested Time Frame: 45 days	**K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.** **K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.** Science and Engineering Practice • **Planning and Carrying Out Investigations** - With guidance, plan and conduct an investigation in collaboration with peers. • **Analyzing and Interpreting Data** – Analyze data from tests on an object or tool to determine if it works as intended. Disciplinary Core Ideas • **PS2.A: Forces and Motion -** Pushes and pulls can have different strengths and directions. • **PS2.A: Forces and Motion** Pushing and pulling on an object can change the speed or direction of its motion and can start or stop it. • **PS2.B: Types of Interactions -** When objects touch or collide, they push on one another and can change motion. • **PS3.C: Relationship Between Energy and Forces -** A bigger push or pull makes things speed up or slow down more quickly. • **ETS1.A: Defining Engineering Problems –** A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Crosscutting Concept • **Cause and Effect –** Simple tests can be designed to gather evidence to support or refute student ideas about causes.

K - 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 foi, roll		Bowl, plastic, 6 quart		Scissors	
Balloons, round pkg/35		Box, cardboard		Stapler	
Cardboard, corrugated, 30 cmX 30 cm		Chips, counting , set/200		Washable Markers	
Clay, modeling, pkg. 4		Cloth, cotton		Yarn	
Cornstarch		Gravel		Glue Sticks	
Craft Sticks, pkg/30		Petri Dishes, pkg/6		Crayons/Markers	
cups, plastic, 9 ounce, pkg/50		Sand, medium grain		Poster paper	
Flour		Soil, potting		Large Lawn Bag	
Pipe Cleaners, pkg/100		Spoon, plastic mxing		Newspaper	
Plates, paper, pkg/50		Strainer		Pencils	
Stir Sticks, pkg/50				Water	
String, cotton				Paper Towels	
Tube, cardboard				Balls	
				Index Cards	
				Counting Chips	
				Construction Paper	
				Hole Punch	
				Tape	
				Construction Paper	
				Copy Paper	

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/.

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/ .

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.

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

BLUE VALLEY DISTRICT CURRICULUM

Science | Grade 1

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

Parents and Offspring: Similarities and Differences **Bring Science Alive!** Unit 1: Plant and Animal Parts Lessons 1 - 2 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.** **Science and Engineering Practice** • **Constructing Explanations and Designing Solutions –** Make observations to construct an evidence-based account for natural phenomena. **Disciplinary Core Ideas** • **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. • **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. **Crosscutting Concept** • **Patterns –** Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.
Plant and Animal Parts **Bring Science Alive!** Unit 1: Plant and Animal Parts Lessons 3-4 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. **Science and Engineering Practice** • **Constructing Explanations and Designing Solutions -** Use materials to design a device that solves a specific problem or a solution to a specific problem. **Disciplinary Core Ideas** • **LS1.A: Structure and Function -** All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. • **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 **Crosscutting Concept** • **Structure and Function** – The shape and stability of structures of natural and designed objects are related to their functions.

Parents and Offspring: Behaviors **Bring Science Alive!** Unit 1: Plant and Animal Parts Lessons 5-8 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. **Science and Engineering Practice** • **Obtaining, Evaluating and Communicating Information** – Read grade-appropriate texts and use media to obtain scientific information to determine patterns in the natural world. **Disciplinary Core Idea** • **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. **Crosscutting Concept** • **Patterns** – Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.
Light **Bring Science Alive!** Unit 2: Light and Sound Lessons 1 - 3 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.** **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. **Science and Engineering Practice** • **Planning and Carrying Out Investigations –** Plan and conduct investigations collaboratively to produce evidence to answer a question. **Disciplinary Core Ideas** • **PS4.B: Electromagnetic Radiation -** Objects can be seen if light is available to illuminate them or if they give off their own light. **Crosscutting Concept** • **Cause and Effect –** Simple tests can be designed to gather evidence to support or refute student ideas about causes.

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

1st Grade 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				Beef Jerky	
Yarn				Cardboard	
Batteries, size D, pkg/6				Fruit Juice	
Cardboard, whit, 8 1/2" X 11"				Straw	
Pan, aluminum				Cup	
				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	

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/.

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SECOND GRADE OVERVIEW

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

PS = Physical Science

LS = Life Science

ESS = Earth Space Science

ETS = Engineering, Technology, and Application of Science

BLUE VALLEY DISTRICT CURRICULUM

Science | Grade 2

ORGANIZING THEME/TOPIC	FOCUS STANDARDS AND SKILLS
Structures and Properties of Matter **Bring Science Alive!** Unit 2: Materials and Their Uses Lessons 1- 5 Suggested Time Frame: 44 days	**2-PS1-1.** **Plan and conduct an investigation to describe and classify** different kinds of materials **by their observable properties.** **Science and Engineering Practices** • **Planning and Carrying Out Investigations –** Plan and conduct an investigation collaboratively to produce data to as the basis for evidence to answer a question. **Disciplinary Core Ideas** • **PS1.A: Structure and Properties of Matter -** Different kinds of matter exist and many of them can be either solid or li depending on temperature. Matter can be described and classified by its observable properties. **Crosscutting Concepts** • **Patterns –** Patterns in the natural and human designed world can be observed. **2-PS1-2.** **Analyze data obtained from testing different materials to determine** which materials **have the properties that are be suited for** an intended purpose. **2-PS1-3.** **Make observations to construct an evidence-based account of how** an object made of a small set of pieces **can be disassembled and made into a new object.** **Science and Engineering Practices** • **Analyzing and Interpreting Data –** Analyze data from tests of an object or tool to determine if it works as intended. • **Constructing Explanations and Designing Solutions –** Make observations to construct an evidence-based account for natural phenomena. **Disciplinary Core Ideas** • **PS1.A: Structure and Properties of Matter -** Different properties are suited to different purposes. • **PS1.A: Structure and Properties of Matter -** A great variety of objects can be built up from a small set of pieces. **Crosscutting Concepts** • **Cause and Effect –** Simple tests can be designed to gather evidence to support or refute student ideas about causes. • **Energy and Matter –** Objects may break into smaller pieces and be put together into larger pieces, or change shapes.

Heating and Cooling Substances **Bring Science Alive!** Unit 2: Materials and Their Uses Lesson 6 Suggested Time Frame: 7 days	**2-PS1-4. Construct an argument with evidence that some changes caused by** heating or cooling can be reversed and some cannot. **Science and Engineering Practices** • **Engaging in Argument from Evidence–** Construct an argument with evidence to support a claim. **Disciplinary Core Idea** • **PS1.B: Chemical Reactions -** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. **Crosscutting Concepts** • **Cause and Effect –** Events have causes that generate observable patterns.
Water on Earth **Bring Science Alive!** Unit 3: Earth's Surface Lessons 1- 2 Suggested Time Frame: 16 days	**2-ESS2-3. Obtain information to identify where water is found on Earth** and that it can be solid or liquid. **Science and Engineering Practices** • **Obtaining, Evaluating, and Communicating Information -** Obtain information using various texts, text features, and other media that will be useful in answering a scientific question. **Disciplinary Core Idea** • **ESS2.C: The Roles of Water in Earth's Surface Processes -** Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. **Crosscutting Concepts** • **Patterns –** Patterns in the natural world can be observed.
Maps of Land and Water **Bring Science Alive!** Unit 3: Earth's Surface Lesson 3 Suggested Time Frame: 10 days	**2-ESS2-2. Develop a model to represent the shapes and kinds** of land and bodies of water in an area. **Science and Engineering Practices** • **Developing and Using Models –** Develop a model to represent patterns in the natural world. **Disciplinary Core Ideas** • **ESS2.B: Plate Tectonics and Large-Scale System Interactions –** Maps show where things are located. One can map the shapes and kinds of land and water in any area. **Crosscutting Concepts** • **Patterns** – Patterns in the natural world can be observed.

Earth Events **Bring Science Alive!** Unit 3: Earth's Surface Lessons 4-7 Suggested Time Frame: 34	**2-ESS1-1. Use information from several sources to provide evidence that** Earth events **can occur quickly or slowly.** **Science and Engineering Practices** • **Constructing Explanations and Designing Solutions –** make observations from several sources to construct an evidence-based account for natural phenomena. **Disciplinary Core Idea** • **ESS1.C: The History of Planet Earth -** Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. **Crosscutting Concepts** • **Stability and Change –** Things may change slowly or rapidly. **2-ESS2-1. Compare multiple solutions designed to slow or prevent** wind or water from changing the shape of the land. **Science and Engineering Practice** • **Constructing Explanations and Designing Solutions** – Compare multiple solutions to a problem. **Disciplinary Core Idea** • **ESS2.A: Earth Materials and Systems -** Wind and water can change the shape of the land. • **ETS1.C: Optimizing the Design Solution –** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. **Crosscutting Concepts** • **Stability and Change –** Things may change slowly or rapidly.
Plant Needs **Bring Science Alive!** Unit 1: Plant and animal Survival Lessons 1- 2 Suggested Time Frame: 18 days	**2-LS2-1. Plan and conduct an investigation** to **determine if** plants **need sunlight and water to grow.** **Science and Engineering Practices** • **Planning and Carrying Out Investigations –** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. **Disciplinary Core Ideas** • **LS2.A: Interdependent Relationships in Ecosystems -** Plants depend on water and light to grow. **Crosscutting Concepts** • **Cause and Effect –** Events have causes that generate observable patterns

Seeds on the Move **Bring Science Alive!** Unit 1: Plant and animal Survival Lessons 3 Suggested Time Frame: 9 days	**2-LS2-2.** **Develop a simple model that mimics the function** of an animal in dispersing seeds or pollinating plants. **Science and Engineering Practices** • **Developing and Using Models –** Develop a simple model based on evidence to represent a proposed object or tool. **Disciplinary Core Ideas** • **LS2.A: Interdependent Relationships in Ecosystems -** Plants depend on animals for pollination or to move their seeds around. • **ETS1.B: Developing Possible Solutions -** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. **Crosscutting Concepts** • **Structure and Function –** The shape and stability of structures of natural and designed objects are related to their function(s).
Diversity and Habitats **Bring Science Alive!** Unit 1: Plant and animal Survival Lessons 4-8 Suggested Time Frame: 43 days	**2-LS4-1.** **Make observations** of plants and animals **to compare** the diversity of life in different habitats. **Science and Engineering Practices** • **Planning and Carrying Out Investigations** - Make observations to collect data which can be used to make comparisons. **Disciplinary Core Ideas** • **LS4.D: Biodiversity and Humans -** There are many different kinds of living things in any area, and they exist in different places on land and in water.

2nd Grade 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			
Cottton Balls, pkg/300		Gravel		Clipboards	
Sand, medium grain		Beads, pkg/100		Clear Tape	
cups, plastic, 9 ounce, pkg/50		Rock Collection		Sticky Notes	
Flour		Wood Block 3" x 4"		Fan	
Bags, paper, pkg/50		Ball, styrene, 3"		Hair Dryer	
cups, paper, 2 ounce, pkg/50		Marbles, 5/8" pkg/20		Spray Bottle	
Paper clips, large, box/100		Spray Bottle		Rain, Sun and Wool Hat	
Pepper, 2 oz		Cloth, cotton		Glue Sticks	
Salt, non-iodized		Bin, plastic, shoe box size		Scissors	
Seeds, Marigold		Wood Cube, 1"		3 X 5 cards	
Steel Wool Pads, pkg/6		**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 (The highlighted item(s)) may need to be purchased through Ward's Science at https://wardsci.com/ .		Tape	
Straws, pkg/50				Yarn	
Swabs, cotton, pkg/30				Construction paper	
Vegetable Oil				Water	
Jar, plastic, 12 oz				Newspaper	
Container, plastic deli				Glue	
Jar, plastic, 16 oz				Markers, Colored Pencils or Crayons	
Sandpaper				Paper Cup	
Tube, cardboard				Plastic baggies	
Cup, paper, 100mL				Banana	
Aluminum foi, roll				Lettuce	
Construction Paper, pkg/50				Milk	
Spoons, plastic, pkg/24		**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/.		Paper Towels	
Wax Paper				Counting Chips	
Sponge				Stapler	
Pipe Cleaners, pkg/100				Plastic spoon	
Stir Sticks, pkg/50				Bucket or large bowl	
Petri Dishes, pkg/6				**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.	
Craft Sticks, pkg/30					
Cardboard, corrugated, 5 cm X 30 cm					
Clay, modeling, pkg. 4					
Bowl, paper					
Soil, potting					

THIRD GRADE OVERVIEW

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

PS = Physical Science

LS = Life Science

ESS = Earth Space Science

ETS = Engineering, Technology, and Application of Science

BLUE VALLEY DISTRICT CURRICULUM

Science | Grade 3

ORGANIZING THEME/TOPIC	FOCUS STANDARDS & SKILLS
Weather Patterns and Predictions **Bring Science Alive!** Unit 3: Weather and Climate Lessons 1 - 5 Suggested Time Frame: 39 days	**3-ESS2-1.** **Represent data in tables and graphical displays to describe** typical weather conditions **expected during a particular season**. **Science and Engineering Practice** • **Analyzing and Interpreting Data -** Represent data in tables and various graphical displays to reveal patterns that indicate relationships. **Disciplinary Core Idea** • **ESS2.D: Weather and Climate -** Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. **Crosscutting Concept** • **Patterns -** Patterns of change can be used to make predictions.
Climates of the World **Bring Science Alive!** Unit 3: Weather and Climate Lessons 6 Suggested Time Frame: 6 days	**3-ESS2-2**. **Obtain and combine information to describe climates in different regions** of the world. **Science and Engineering Practice** • **Obtaining, Evaluating, and Communicating Information -** Obtain and combine information from books and other reliable media to explain phenomena. **Disciplinary Core Idea** • **ESS2.D: Weather and Climate -** Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. **Crosscutting Concept** • **Patterns -** Patterns of change can be used to make predictions.

Weather Related Hazards **Bring Science Alive**! Unit 3: Weather and Climate Lessons 7-8 Suggested Time Frame: 13 days	**3-ESS3-1.** **Make a claim about the merit of a design solution that reduces the impacts of** a weather-related hazard. **Science and Engineering Practice** • **Engaging in Argument from Evidence -** Make a claim about the merit of a solution to a problem by citing relevant evidence about hot it meets the criteria and constraints of the problem. **Disciplinary Core Idea** • **ESS3.B: Natural Hazards -** A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. **Crosscutting Concept** • **Cause and Effect -** Cause and effect relationships are routinely identified, tested, and used to explain change.
Balanced and Unbalanced Forces **Bring Science Alive!** Unit 2: Forces and Motion Lessons 1 - 2 Suggested Time Frame: 13 days	**3-PS2-1.** **Plan and conduct an investigation to provide evidence of the effects** of balanced and unbalanced forces on the motion of an object. **Science and Engineering Practice** • **Planning and Carrying Out Investigations -** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. **Disciplinary Core Idea** • **PS2.A: Forces and Motion -** Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion**.** • **PS2.B: Types of Interactions -** Objects in contact exert forces on each other. **Crosscutting Concept** • **Cause and Effect -** Cause and effect relationships are routinely identified.

Predicting Motions **Bring Science Alive!** Unit 2: Forces and Motion Lesson 3 Suggested Time Frame: 7 days	**3-PS2-2.** Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. Science and Engineering Practice • **Planning and Carrying Out Investigations -** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of phenomenon or test a design solution. Disciplinary Core Idea • **PS2.A: Forces and Motion -** The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. Crosscutting Concept • **Patterns -** Patterns of change can be used to make predictions.
Magnetism and Electricity **Bring Science Alive!** Unit 2: Forces and Motion Lessons 4- 5 Suggested Time Frame: 14 days	**3-PS2-3.** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. **3-PS2-4.** Define a simple design problem that can be solved by applying scientific ideas about magnets. Science and Engineering Practice • **Asking Questions and Defining Problems -** Ask questions that can be investigated based on patterns such as cause and effect relationships. • **Asking Questions and Defining Problems -** Define a simple problem that can be solved through the development of a new or improved object or tool. Disciplinary Core Idea • **PS2.B: Types of Interactions -** Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. Crosscutting Concept • **Cause and Effect -** Cause and effect relationships are routinely identified, tested and used to explain change. • **Interdependence of Science, Engineering and Technology -** Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process.

Survival of Organisms **Bring Science Alive!** Unit 1: Environments and Living Things Lessons 1 - 4 Suggested Time Frame: 28 days	**3-LS2-1. Construct an argument that** some animals **form groups that help** members survive. **Science and Engineering Practice** • **Engaging in Argument from Evidence -** Construct an argument with evidence, data, and/or a model **Disciplinary Core Idea** • **LS2.D: Social Interactions and Group Behavior -** Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size. **Crosscutting Concept** • **Cause and Effect -** Cause and effect relationships are routinely identified and used to explain change. **3-LS4-3. Construct an argument with evidence that** in a particular habitat some organisms **can survive well, some survive less well, and some cannot survive at all**. **Science and Engineering Practice** • **Engaging in Argument from Evidence -** Construct an argument with evidence. **Disciplinary Core Idea** • **LS4.C: Adaptation -** For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. **Crosscutting Concept** • **Cause and Effect -** Cause and effect relationships are routinely identified and used to explain change. **3-LS4-4. Make a claim about the merit of a solution to a problem** caused when **the environment changes and the types of plants and animals that live there** may change. **Science and Engineering Practice** • **Engaging in Argument from Evidence -** Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. **Disciplinary Core Idea** • **LS4.D: Biodiversity and Humans -** Populations live in a variety of habitats, and change in those habitats affects the organisms living there. • **LS2.C: Ecosystem Dynamics, Functioning, and Resilience -** When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. **Crosscutting Concept** • **Systems and System Models -** A system can be described in terms of its components and their interactions.

Fossils **Bring Science Alive!** Unit 1: Environments and Living Things Lessons 5-6 Suggested Time Frame: 15 days	**3-LS4-1.** **Analyze and interpret data** from fossils to provide evidence of the organisms and the environments in which they lived **long ago**. **Science and Engineering Practice** • **Analyzing and Interpreting Data -** Analyze and interpret data to make sense of phenomena using logical reasoning. **Disciplinary Core Idea** • **LS4.A: Evidence of Common Ancestry and Diversity -** Some kinds of plants and animals that once lived on Earth are no longer found anywhere. • **LS4.A: Evidence of Common Ancestry and Diversity** - Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. **Crosscutting Concept** • **Scale, Proportion, and Quantity -** Observable phenomena exist from very short to very long time periods.
Inheritance and Variation of Traits **Bring Science Alive!** Unit 4: Life Cycles and Traits Lessons 1 - 3 Suggested Time Frame: 16 days	**3-LS3-1.** **Analyze and interpret data to provide evidence that** plants and animals have traits inherited from parents and that **variation of these traits exists in a group of similar** organisms**.** **3-LS3-2.** **Use evidence to support the explanation that** traits **can be influenced by** the environment. **Science and Engineering Practice** • **Analyzing and Interpreting Data -** Analyze and interpret data to make sense of phenomena using logical reasoning. • **Constructing Explanations and Designing Solutions -** Use evidence to support an explanation. **Disciplinary Core Idea** • **LS3.A: Inheritance of Traits -** Many characteristics of organisms are inherited from their parents. • **LS3.A: Inheritance of Traits** - Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. • **LS3.B: Variation of Traits -** Different organisms vary in how they look and function because they have different inherited information. • **LS3.A: Inheritance of Traits** - The environment also affects the traits that an organism develops. **Crosscutting Concept** • **Patterns -** Similarities and differences in patterns can be used to sort and classify natural phenomena**.** • **Cause and Effect -** Cause and effect relationships are routinely identified and used to explain change**.**

Natural Selection **Bring Science Alive!** Unit 4: Life Cycles and Traits Lesson 4 Suggested Time Frame: 6 days	**3-LS4-2.** **Use evidence to construct an explanation** for how the variations in characteristics among individuals of the same species **may provide advantages** in surviving, finding mates, and reproducing. **Science and Engineering Practice** • **Constructing Explanations and Designing Solutions -** Use evidence to construct an explanation **Disciplinary Core Idea** • **LS4.B: Natural Selection -** Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. **Crosscutting Concept** • **Cause and Effect -** Cause and effect relationships are routinely identified and used to explain change.
Life Cycles **Bring Science Alive!** Unit 4: Life Cycles and Traits Lessons 5-7 Suggested Time Frame: 22 days	**3-LS1-1.** **Develop models to describe that** organisms have unique and diverse life cycles **but all have in common** birth, growth, reproduction, and death. **Science and Engineering Practice** • **Developing and Using Models -** Develop models to describe phenomena **Disciplinary Core Idea** • **LS1.B: Growth and Development of Organisms -** Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. **Crosscutting Concept** • **Patterns -** Patterns of change can be used to make predictions.

3rd Grade 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 (provided in the initial kits)				Teacher/Student Provided Materials	
Consumables Materials		Non-Consumables Materials		Teacher/Student Provided Materials	
Clay, modeling, pkg. 4		Balls, hi bounce 1" pkg/6		Dark Markers	
Balloons, round pkg/35		Forceps, pkg/6		Pencils	
Yarn		Nails, pkg/15		Rulers	
Batteries, size D, pkg/6		Rain Gauge		Scissors	
Bowls, foam, 12 ounce, pkg/25		Bowl, plastic, 6 quart		Stapler	
Coupon, Butterfly Habitat and Larvae		Cloth, wool		Water	
Cups, paper, 200 mL, pkg/25		Spring Toy, metal		Masking Tape	
Cardboard, corrugated, 30 cmX 30 cm		Meter Stick, folding		Glue	
Aluminum foil, roll		Box, cardboard		Newspaper	
Paper clips, large, box/100		Battery Holder, size D		Construction paper	
String, cotton		Magnets, Bar, pkg/2		Paper Towels	
Wire, insulated copper		Pulley with table clamp		Notebook or Printer Paper	
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/.		Spring Scale		Boxes or tubs for 8 ½ x 11 paper	
		Thermometer		Plastic Cup	
		Container, plastic deli		Sunflower Seeds Unshelled	
		Lid for plastic deli container		Sand	
		Washers, metal, 3/4", box/100		Audio Recording Device	
		Stopwatch		Art supplies	
		Bin, plastic, shoe box size		Prop Box Unit 3 (weather related)	
		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/ .		Weather Station building materials (yarn, chairs, books, etc.)	
				Black Butcher Paper	
				White Butcher Paper	
				Hand Lenses (optional)	
				Prop Box Unit 1	
				Bed sheet or Shower curtain (optional)	
				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.	

FOURTH GRADE OVERVIEW

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

PS = Physical Science

LS = Life Science

ESS = Earth Space Science

ETS = Engineering, Technology, and Application of Science

BLUE VALLEY DISTRICT CURRICULUM

Science | Grade 4

ORGANIZING THEME/ TOPIC	FOCUS STANDARDS & SKILLS
Energy & Motion **Bring Science Alive!** Unit 2 Energy Lessons 1-2 Suggested Time Frame: 14 days	**4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.** Science and Engineering Practice • **Constructing Explanations and Designing Solutions –** Use evidence (e.g., measurements, observations, patterns) to construct an explanation. Disciplinary Core Ideas • **PS3.A: Definitions of Energy -** The faster a given object is moving, the more energy it possesses. Crosscutting Concept • **Energy and Matter –** Energy can be transferred in various ways and between objects. **4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.** Science and Engineering Practice • **Asking Questions and Defining Problems –** Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. Disciplinary Core Ideas • **PS3.A: Definitions of Energy -** Energy can be moved from place to place by moving objects or through sound, light, or electric currents. • **PS3.B: Conservation of Energy and Energy Transfer -** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • **PS3.C: Relationship Between Energy and Forces -** When objects collide, the contact forces transfer energy so as to change the objects' motions. Crosscutting Concept • **Energy and Matter –** Energy can be transferred in various ways and between objects.

Energy Transfer **Bring Science Alive!** Unit 2 Energy Lessons 3 - 4 Suggested Time Frame: 13 days	**4-PS3.2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electric currents.** **Science and Engineering Practice** • **Planning and Carrying Out Investigations** – Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. **Disciplinary Core Ideas** • **PS3.A: Definitions of Energy -** Energy can be moved from place to place by moving objects or through sound, light, or electric currents. • **PS3.B: Conservation of Energy and Energy Transfer -** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • **PS3.B: Conservation of Energy and Energy Transfer -** Light also transfers energy from place to place. • **PS3.B: Conservation of Energy and Energy Transfer -** Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. **Crosscutting Concept** • **Energy and Matter –** Energy can be transferred in various ways and between objects.
Energy Transfer **Bring Science Alive!** Unit 2 Energy Lesson 5 Suggested Time Frame: 7 days	**4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.** **Science and Engineering Practice** • **Constructing Explanations and Designing Solutions** – Apply scientific ideas to solve design problems. **Disciplinary Core Ideas** • **PS3.B: Conservation of Energy and Energy Transfer -** Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. • **PS3.D: Energy in Chemical Processes and Everyday Life -** The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. • **ETS1.A: Defining Engineering Problems -** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. **Crosscutting Concept** • **Energy and Matter –** Energy can be transferred in various ways and between objects.

<table>
<tr>
<td>Natural Resources

Bring Science Alive!
Unit 2 Energy
Lesson 6
Suggested Time Frame:

Suggested Time Frame: 6 days</td>
<td>4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Science and Engineering Practice
• Obtaining, Evaluating, and Communicating Information – Obtain and combine information from books and other reliable media to explain phenomena.
Disciplinary Core Ideas
• ESS3.A: Natural Resources - Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.
Crosscutting Concept
• Cause and Effect – Cause and effect relationships are routinely identified and used to explain change.</td>
</tr>
<tr>
<td>Earth's Changing Surface

Bring Science Alive!
Unit 3 Earth's Changing Surface
Lessons 1-5

Suggested Time Frame: 32 days</td>
<td>4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

Science and Engineering Practices
• Constructing Explanations and Designing Solutions – Identify the evidence that support particular points in an explanation.
Disciplinary Core Idea
• ESS1.C: The History of Planet Earth - Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.
Crosscutting Concept
• Patterns – Patterns can be used as evidence to support an explanation.

4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind or vegetation.

Science and Engineering Practices
• Planning and Carrying Out Investigations – Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
Disciplinary Core Idea
• ESS2.A: Earth Materials and Systems - Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.
• ESS2.E: Biogeology - Living things affect the physical characteristics of their regions.
Crosscutting Concept
• Cause and Effect – Cause and effect relationships are routinely identified, tested, and used to explain change.</td>
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Patterns of Earth's Features **Bring Science Alive!** Unit 3 Earth's Changing Surface Lesson 6 Suggested Time Frame: 7 days	**4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.** **Science and Engineering Practices** • **Analyzing and Interpreting Data – Analyze and interpret data to make sense of phenomena using logical reasoning.** **Disciplinary Core Idea** • **ESS2.B: Plate Tectonics and Large-Scale System Interactions -** The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. **Crosscutting Concept** • **Patterns –** Patterns can be used as evidence to support an explanation.
Natural Hazards: Impacts on Humans **Bring Science Alive!** Unit 3 Earth's Changing Surface Lesson 7 Suggested Time Frame: 7 days	**4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.** **Science and Engineering Practices** • **Constructing Explanations and Designing Solutions –** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. **Disciplinary Core Idea** • **ESS3.B: Natural Hazards -** A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. • **ETS1.B: Designing Solutions to Engineering Problems –** testing a solution involves investigating how well it performs under a range of likely conditions. **Crosscutting Concept** • **Cause and Effect** – Cause and effect relationships are routinely identified, tested, and used to explain change.

Earth's Systems: Wave **Bring Science Alive!** Unit 4 Waves and Information Lessons 1 - 4 Time Frame: 26 days	**4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.** **Science and Engineering Practices** • **Developing and Using Models –** Develop a model using an analogy, example, or abstract representation to describe a scientific principle. **Disciplinary Core Idea** • **PS4.A: Wave Properties -** Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. • **PS4.A: Wave Properties** Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). **Crosscutting Concept** • **Patterns –** Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.
Digitized Information **Bring Science Alive!** Unit 4 Waves and Information Lessons 5-6 Suggested Time Frame: 14 days	**4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.** **Science and Engineering Practices** • **Constructing Explanations and Designing Solutions –** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. **Disciplinary Core Idea** • **PS4.C: Information Technologies and Instrumentation -** Digitized information can be 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. • **ETS1.C: Optimizing The Design Solution –** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. **Crosscutting Concept** • **Patterns –** Similarities and differences in patterns can be used to sort and classify designed products.
Plants and Animals: Structure and Function **Bring Science Alive!** Unit 1 Plant and Animal Structures Lessons 1-7 Suggested Time Frame: 44 days	**4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** **Science and Engineering Practices** • **Engaging in Argument from Evidence –** Construct an argument with evidence, data and/or a model. **Disciplinary Core Idea** • **LS1.A: Structure and Function -** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. **Crosscutting Concept** • **Systems and System Models –** A system can be described in terms of its components and their interactions.

Sight and Sense Receptors **Bring Science Alive!** Unit 1 Plant and Animal Structures Lessons 8-9 Suggested Time Frame: 13 days	**4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** **Science and Engineering Practices** • **Developing and Using Models –** Develop a model to describe phenomena**.** **Disciplinary Core Idea** • **PS4.B: Electromagnetic Radiation -** An object can be seen when light reflected from its surface enters the eyes. **Crosscutting Concept** • **Cause and Effect –** Cause and effect relationships are routinely identified. **4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** **Science and Engineering Practices** • **Developing and Using Models –** Use a model to test interactions concerning the functioning of a natural system. **Disciplinary Core Idea** **LS1.D: Information Processing -** Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. **Crosscutting Concept** • **Systems and System Models –** A system can be described in terms of its components and their interactions.

4th Grade 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		Animal Cage, plastic		Celery	
Bags, paper, pkg/50		Bottle, plastic with hinged cap		Scissors	
Bags, plastic sandwich size, pkg/80		Forceps, pkg/6		Water	
Cotton Balls, pkg/300		Spray Bottle		Red Food Coloring	
Cup, plastic souffle, 4 oz		Ball, styrene, 2”		Blue Food Coloring	
Detergent, liquid		Beaker, 250 mL		Newspaper	
Feathers, down, pkg/200		Battery Connector, 9 V		Flowers	
Knives, plastic, pkg/24		Bin, plastic, shoe box size		Tape	
Pill or Sow Bugs Coupon		Buzzer		Colored Pencils	
Toothpicks, flat, pkg/750		Light Sockets, miniature, pkg/6		Green Construction Paper	
Tube, cardboard, 12”		Marbles, 1” pkg/6		Brown Yarn	
Wax Paper		Motor, electric		Hole Punch	
Balloons, round, pkg/6		Spring Toy, metal		String	
Bowl, paper		Switches with clips, pkg/2		Crushed Leaves	
Box, cardboard		Washers, 1-1/2”, pkg/6		Potato or Apple Peel	
Brass Paper Fasteners, pkg/100		**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/ .		Paper Towels	
Cardboard, corrugated, 30 cm x 50 cm				Straight Pin	
CD Case				Masking Tape	
Container, plastic, 2 qt				Rulers	
File Folder				Utility Knife	
Fishing Line				Construction Paper	
Flour				Sticky Notes	
Jar, plastic, 12 oz				Ice Cubes	
Lid for 2 qt container				Grass Clippings	
Meter Stick, folding		**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/.		Paper Clips	
Pans, aluminum				Soil and Potting Mix	
Paper Clips, small, box/100				Coffee or Tea	
Battery, 9V				Crayons/Markers/Colored Pencils	
Clay, modeling, pkg/4				Wipes/Paper Towels	
Clothespins, pkg/18				Coins	
Craft Sticks, pkg/30				D Batteries	
Cups, paper, 200 mL, pkg/25				Poster Paper	
Hand Lenses, pkg/6				Newspaper	
Light Bulbs, miniature, pkg/12		**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.		Scale	
Paper Clips, large, box/100				Objects to act as wind obstacles: model trees, houses, rocks, pebbles, paper tents, blocks. Etc.	
Plastic Wrap					
Rubber Bands, #33				Manila Folders	
Straws, pkg/50				Rulers	
String, cotton				Pencils and Pens	
Sand, medium grain				Straws	
Soil, potting					

FIFTH GRADE OVERVIEW

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

PS = Physical Science

LS = Life Science

ESS = Earth Space Science

ETS = Engineering, Technology, and Application of Science

BLUE VALLEY DISTRICT CURRICULUM

Science | Grade 5

ORGANIZING THEME/TOPIC	FOCUS STANDARDS & SKILLS
Matter **Bring Science Alive!** Unit 3: Changes in Matter Lessons 1- 2 Suggested Time Frame: 11 days	**5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.** Science and Engineering Practice • **Developing and Using Models –** Use models to represent events and design solutions. Disciplinary Core Idea • **PS1.A Structure and Properties of Matter -** Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from moving particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. Crosscutting Concept • **Scale, proportion, and Quantity** – Natural objects exist from the very small to the immensely large.
Materials and Their Properties **Bring Science Alive!** Unit 3: Changes in Matter Lessons 3-5 Suggested Time Frame: 18 days	**5-PS1-3 Make observations and measurements to identify materials based on their properties.** Science and Engineering Practice • **Planning and Carrying Out Investigations –** Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. Disciplinary Core Idea • **PS1.A Structure and Properties of Matter -** Measurements of a variety of properties can be used to identify materials. Crosscutting Concept • **Scale, proportion, and Quantity** – Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. **5-PS1-4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances.** Science and Engineering Practice • **Planning and Carrying Out Investigations –** Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of traits considered. Disciplinary Core Idea • **PS1.B Chemical Reactions -** When two or more different substances are mixed, a new substance with different properties may be formed. Crosscutting Concept • **Cause and Effect –** Cause and effect relationships are routinely identified and used to explain change.

Conservation of Matter **Bring Science Alive!** Unit 3: Changes in Matter Lessons 6 – 7 Suggested Time Frame: 14 days	**5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.** **Science and Engineering Practice** • **Using Mathematics and Computational Thinking –** Measure and graph quantities such as weight to address scientific and engineering questions and problems. **Disciplinary Core Idea** • **PS1.A Structure and Properties of Matter -** The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. • **PS1.B Chemical Reactions -** No matter what reaction or change in properties occurs, the total weight of the substances does not change. **Crosscutting Concept** • **Scale, Proportion, and Quantity** – Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
Producers in an Ecosystem **Bring Science Alive!** Unit 1: Living Things and Ecosystems Lessons 1-2 Suggested Time Frame: 12 days	**5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.** **Science and Engineering Practice** • **Engaging in Argument from Evidence – Support an argument with evidence, data, or a model.** **Disciplinary Core Idea** • **LS1.C Organization for Matter and Energy Flow in Organisms -** Plants acquire their material for growth chiefly from air and water. **Crosscutting Concept** • **Energy and Matter** – Matter is transported into, out of , and within systems

Consumers in an Ecosystem **Bring Science Alive!** Unit 1: Living Things and Ecosystems Lessons 3 Suggested Time Frame: 7 days	**5-PS3-1** Use models to describe **that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth)** was once energy from the sun. Science and Engineering Practice • **Developing and using Models –** Use models to describe phenomena. Disciplinary Core Idea • **PS3.D Energy in Chemical Processes and Everyday Life -** The energy released (from) food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). • **LS1.C Organization for Matter and Energy Flow in Organisms -** Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. Crosscutting Concept • **Energy and Matter –** Energy can be transferred in various ways and between objects.
Food Webs **Bring Science Alive!** Unit 1: Living Things and Ecosystems Lessons 4-8 Suggested Time Frame: 39 days	**5-LS2-1** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. Science and Engineering Practice • **Developing and Using Models –** Develop a model to describe a phenomena. Disciplinary Core Idea • **LS2.A Interdependent Relationships In Ecosystems -** The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. • **LS2.B Cycles of Matter and Energy Transfers -** Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. Crosscutting Concept • **Systems and System Models –** A system can be described in terms of its components and their interactions.

Interaction of Earth Systems **Bring Science Alive!** Unit 2: Earth Systems Lessons 1-3 Suggested Time Frame: 17 days	**5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and /or atmosphere interact.** **Science and Engineering Practice** • **Developing and Using Models –** Develop a model using an example to describe a scientific principle. **Disciplinary Core Idea** • **ESS2.A: Earth Materials and Systems -** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. **Crosscutting Concept** • **Systems and System Models –** A system can be described in terms of its components and their interactions. **5-ESS2-2 Describe and graph the amount and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.** **Science and Engineering Practice** • **Using Mathematics and Computational Thinking** – Describe and graph quantities such as area and volume to address scientific questions. **Disciplinary Core Idea** • **ESS2.C: The Roles of Water in Earth's Surface Processes -** Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. **Crosscutting Concept** • **Scale, Proportion, and Quantity** – Standard units are used to measure and describe physical quantities such as weight and volume.

Human Impacts on Earth Systems **Bring Science Alive!** Unit 2: Earth Systems Lessons 4-6 Suggested Time Frame: 20 days	5**-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment** **Science and Engineering Practice** • **Obtaining, Evaluating, and Communicating Information –** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. **Disciplinary Core Idea** • **ESS3.C: Human Impacts on Earth Systems -** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. **Crosscutting Concept** • **Systems and System Models –** A system can be described in terms of its components and their interactions.
Gravity **Bring Science Alive!** Unit 4: Earth, the Moon and the Stars Lesson 1 Suggested Time Frame: 5 days	**5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.** **Science and Engineering Practice** • **Engaging in Argument from Evidence –** Support an argument with evidence, data or a model **Disciplinary Core Idea** • **PS2.B: Types of Interactions -** The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. **Crosscutting Concept** • **Cause and Effect –** Cause and effect relationships are routinely identified and used to explain change.
Our Sun and the Stars **Bring Science Alive!** Unit 4: Earth, the Moon and the Stars Lessons 2 and 7 **STAR LAB** Suggested Time Frame: 13 days	**5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.** **Science and Engineering Practice** • **Engaging in Argument from Evidence –** Support an argument with evidence, data or a model **Disciplinary Core Idea** • **ESS1.A: The Universe and its Stars -** The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. **Crosscutting Concept** • **Scale, Proportion, and Quantity –** Natural objects exist from the very small to the immensely large.

Patterns in the Sky **Bring Science Alive!** Unit 4: Earth, the Moon and the Stars Lessons 3-6 **STAR LAB** Suggested Time Frame: 25 days	**5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.** **Science and Engineering Practice** • **Analyzing and Interpreting Data –** Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. **Disciplinary Core Idea** • **ESS1.B: Earth and the Solar System -** The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. **Crosscutting Concepts** • **Cause and Effect –** Cause and effect relationships are routinely identified and used to explain change.

5th Grade 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			
Antacid Tablets, pkg/2		Balance, triple beam		Newspaper	
Baking Powder		Beaker, 250 mL		Paper towels	
Balloons, round, pkg/35		Beakers, 250 mL, pkg/10		Garbage bag	
Batteries, size D, pkg/6		Droppers, pkg/6		Disposable gloves	
Bowl, paper		Earth Model, inflatable		Disinfectant	
Calcium Chloride		Flashlight		Making Tape	
Chalk, white		Graduated Cylinder, 100 mL		Water	
Cotton Balls, pkg/300		Gravel			
Craft Sticks, pkg/30		Hand Lenses, pkg/6		Water Bottle with Cap	
Cups, paper, 200 mL, pkg/25		Lens, double concave, FL 10 cm		Scissors	
Cups, plastic medicine, 30 mL, pkg/50		Lens, double concave, FL 5 cm		Construction paper	
Filter, coffee		Lens, double convex, FL 10 cm		Tape	
Flour		Lens, double convex, FL 15 cm		Colored Pencils/Markers	
Food Coloring, set/4		Light Socket, porcelain w/cord		Paper bowl	
Iodine Solution, 1.85%, 100 mL		Ruler		Chocolate Chip Cookies	
Jar, plastic, clear, 4 oz.		Washers, metal, 3/4", box/100		Rulers	
Lid for plastic jar		Container, plastic, 2 qt		Small rocks	
Light Bulb, 60 W		Forceps, pkg/6		Sugar	
Paper Clips, large, box/100		Bin, plastic, shoe box size		Whipping Cream	
Plates, paper, pkg/50		Poster, Owls and Owl Pellets		Stickers	
Sponge		**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/ .		Sticky Notes	
Spoons, plastic, pkg/24				Pencils	
Talc, powder				Poster Board or Butcher Paper	
Toothpicks, flat, pkg/750				**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.	
Tube, cardboard					
Wood, balsa					
Yarn					
Beads, pkg/100					
Clay, modeling, pkg/4					
Cloth, cotton					
Forks, plastic, pkg/24		**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/.			