Arizona Science Standards
2018

Arizona Department of Education

High Academic Standards for Students

3rd - 5th Grade

Introduction

Students are naturally curious about the world and their place in it. Sustaining this curiosity and giving it a scientific foundation must be a high priority in Arizona schools. Scientific thinking enables Arizona students to strengthen skills that people use every day: solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing lifelong learning. A fundamental goal of science education is to help students determine how the world works and make sense of phenomena in the natural world. Phenomena are events or situations that are observed to exist or happen, especially phenomena whose causes or explanations are in question. Science sense-making is a conceptual process in which a learner actively engages with phenomena in the natural world to construct logical and coherent explanations that incorporate their current understanding of science or a model that represents it, and are consistent with the available evidence. To develop a scientific understanding of the natural world, students must be able to ask questions, gather information, reason about that information and connect it to scientific principles, theories, or models, and then effectively communicate their understanding and reasoning.

Purpose of the Arizona Science Standards

The Arizona Science Standards present a vision of what it means to be scientifically literate, and college and career ready. These standards outline what all students need to know, understand, and be able to do by the end of high school and reflect the following shifts for science education:

- Organize standards around fourteen core ideas and develop learning progressions to coherently and logically build scientific literacy from kindergarten through high school.
- Connect **core ideas**, **crosscutting concepts**, and **science and engineering practices**, to make sense of the natural world and understand how science and engineering are practiced and experienced.
- Focus on fewer, broader standards that allow for greater depth, more connections, deeper understanding, and more applications of content.

The standards are neither curriculum nor instructional practices.
While the Arizona Science Standards serve as the basis for a district's or school's science curriculum, they are not the curriculum. Therefore, identifying the sequence of instruction at each grade – what will be taught and for how long – requires concerted effort and attention at the local level. Curricular tools, including textbooks, are selected by the district/school and adopted through the local governing board. The Arizona Department of Education defines standards, curriculum, and instruction as:

- **Standards** are what a student needs to know, understand, and be able to do by the end of each grade. They build across grade levels in a progression of increasing understanding and through a range of cognitive demand levels. Standards are adopted at the state level by the Arizona State Board of Education.
- **Curriculum** refers to resources used for teaching and learning the standards. Curricula are adopted at the local level.
- **Instruction** refers to the methods or methodologies used by teachers to teach their students. Instructional techniques are employed by individual teachers in response to the needs of the students in their classes to help them progress through the curriculum to master the standards. Decisions about instructional practice and techniques are made at a local level.

Three Dimensions of Science
Sense-making in science occurs with the integration of three essential dimensions:

- **science and engineering practices** (shown as the outer ring in Figure 1)
- **crosscutting concepts** (shown as the middle section of Figure 1)
- **core ideas** (shown as the center circle in Figure 1)

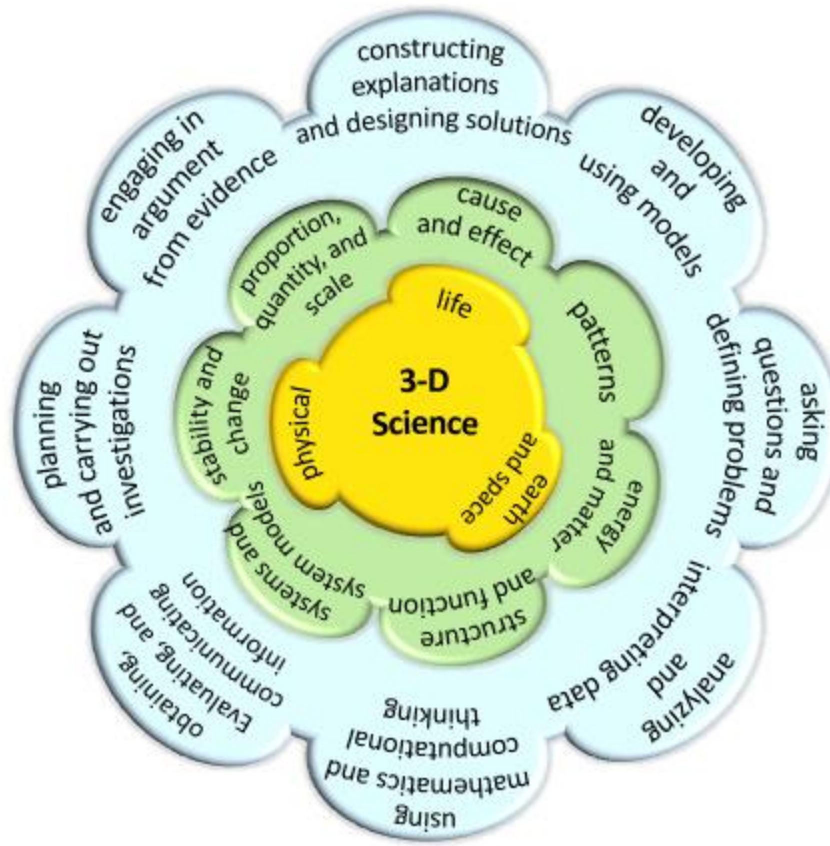


Figure 1: Three Dimensions of Science Instruction

Science and Engineering Practices

For decades teachers have utilized the scientific method as a methodology to engage in scientific inquiry. How it has been implemented in classrooms describes a set of prescribed steps used to engage in science teaching and to learn in a rather linear process. The new vision calls for students to engage in multifaceted science and engineering practices in more complex, relevant, and authentic ways. The science and engineering practices[4] describe a robust process for how scientists investigate and build models and theories of the natural world or how engineers design and build systems. Rather than a linear process from hypothesis to conclusion, these practices reflect science and engineering as they are practiced and experienced. As students conduct investigations, they engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena. Student investigations may be observational, experimental, use models or simulations, or use data from other sources. These eight practices identified in *A Framework for K-12 Science Education*[4] are critical components of scientific literacy, not instructional strategies:

- ask questions and define problems
- develop and use models
- plan and carry out investigations
- analyze and interpret data
- use mathematics and computational thinking
- construct explanations and design solutions
- engage in argument from evidence
- obtain, evaluate, and communicate information

While the scientific method is still being widely used, and a part of academics, the science and engineering practices are expected to be integrated with the core ideas and crosscutting concepts across all grade levels and disciplines. See Appendix 2 for more details on each of the science and engineering practices.

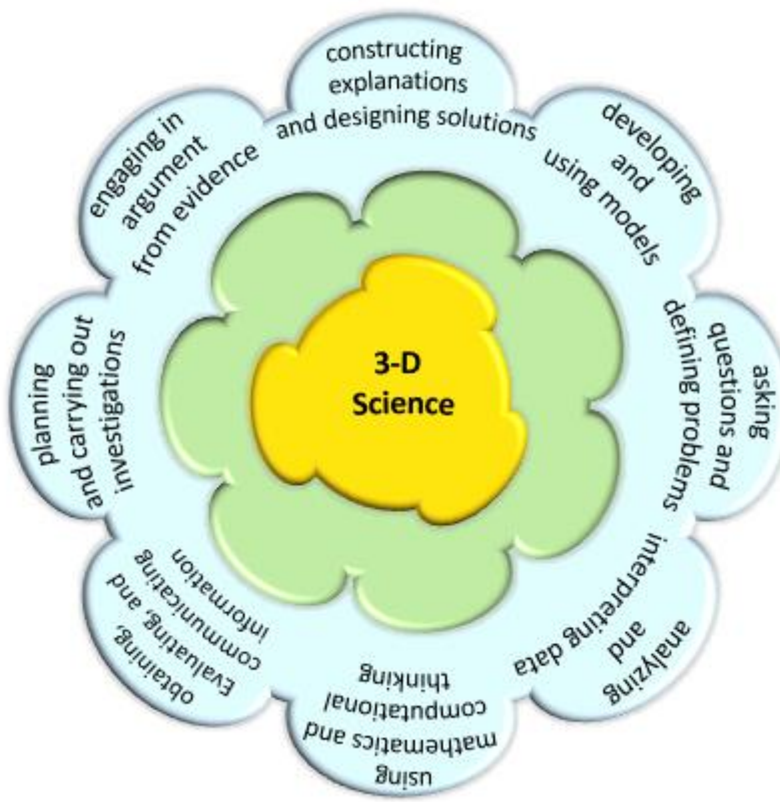


Figure 2: Science and engineering practices are used to

Crosscutting Concepts

Crosscutting concepts[4] cross boundaries between science disciplines and provide an organizational framework to connect knowledge from various disciplines into a coherent and scientifically based view of the world. They bridge boundaries between science and other disciplines and connect core ideas and practices throughout the fields of science and engineering. Their purpose is to provide a lens to help students deepen their understanding of the core ideas as they make sense of phenomena in the natural and designed worlds. The crosscutting concepts identified in *A Framework for K-12 Science Education* are:

- patterns
- cause and effect
- structure and function
- systems and system models
- stability and change
- scale, proportion, and quantity
- energy and matter

The Arizona Science Standards are designed for students to develop their understanding of core ideas through the lens of one or multiple crosscutting concepts. Crosscutting concepts can be combined as students find and use patterns as evidence, determine cause and effect relationships, or define systems to investigate. Students must be provided with structures and opportunities to make explicit connections between their learning and the crosscutting concepts. See Appendix 1 for more details on each of the crosscutting concepts.

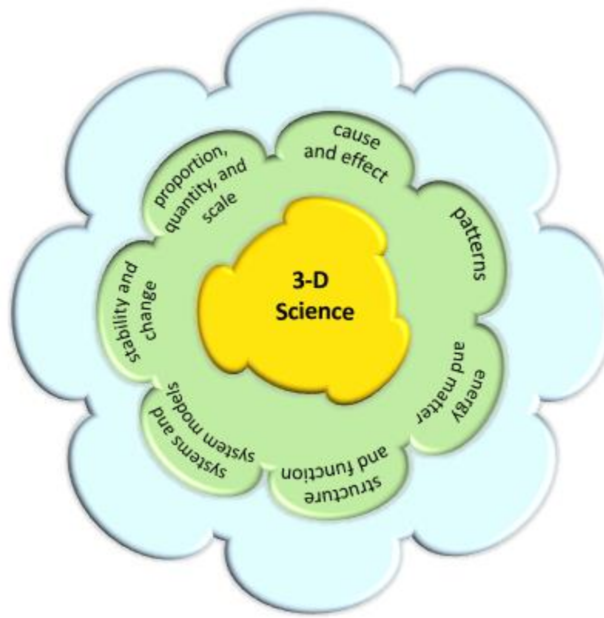


Figure 3: Crosscutting concepts provide a lens for understanding the core ideas

The use of crosscutting concepts can be demonstrated within cause and effect relationships. For example, researchers investigate cause and effect mechanisms in the motion of a single object, specific chemical reactions, population changes in an ecosystem, and the development of holes in the polar ozone layers. Patterns are present in all science disciplines, and much of science is about explaining observed patterns. Using data, graphs, charts, maps, and statistics in combination with the science and engineering practices, students can use their knowledge of cause and effect relationships to formulate investigations, answer questions, and make informed predictions about observed phenomena.

Core Ideas

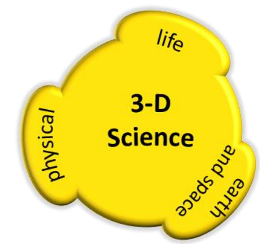


Figure 4: Core ideas for knowing science and using science develop scientific literacy through science content knowledge, understanding the nature of science, applications of science and engineering, and social implications

The Arizona Science Standards focus on fourteen core ideas in science and engineering, adapted from *Working with Big Ideas of Science Education*.[2] The ten core ideas for **Knowing Science** center on understanding the causes of phenomena in physical, earth and space, and life science. The core ideas for **Using Science** connect scientific principles, theories, and models; engineering and technological applications; and societal implications to the content knowledge to support that understanding. The complexity of each core idea develops as students' progress through each grade band. Each standard is written at the intersection of two core ideas to help students understand both the process of knowing science and using science. These core ideas occur across grade levels and provide the background knowledge for students to develop sense-making around phenomena in the natural world. See Appendix 3 for more details. The core ideas are listed below.

Core Ideas for Knowing Science		Core Ideas for Using Science
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it. P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. **Earth and Space Science** E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. **Life Science** L1: Organisms are organized on a cellular basis and have a finite life span. L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. L3: Genetic information is passed down from one generation of organisms to another. L4: The unity and diversity of organisms, living and extinct, is the result of evolution. ***Adapted from *Working with Big Ideas in Science Education*[2]**		U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Time Allotment

The Arizona Science Standards suggest students have regular standards-based science instruction every year. The amount of time individual students need to learn these standards will vary. The chart below specifies the instructional time necessary for students to master these standards.

The Arizona Science Standards have been designed so that these time suggestions provide adequate time to actively engage in all 3 dimensions of science instruction to master the standards for each grade level. *Depending on local factors, schools may allocate more or less time when determining curriculum programming within a specific context. Instruction on the Arizona Science Standards may be a dedicated time in the school schedule or may be integrated with the instruction of other subjects.* See Appendix 5 and the Standards document for connections with other content areas.

These time recommendations do not explicitly address the needs of students who are far below or far above the grade level.
No set of grade-specific standards can fully reflect the variety of abilities, needs, learning rates, and achievement levels of students in any given classroom. The Arizona Science Standards do not define the intervention methods to support students who are far below or far above grade level or do not speak English as their first language. See Appendix 4 for strategies to support equity and diversity in science.

Grade	Suggested Minutes per Week	Suggested Average Minutes per Day
K	90 minutes/week	18 minutes/day
1	150 minutes/week	30 minutes/day
2	150 minutes/week	30 minutes/day
3	200 minutes/week	40 minutes/day
4	225 minutes/week	45 minutes/day
5	225 minutes/week	45 minutes/day
6	250 minutes/week	50 minutes/day
7	250 minutes/week	50 minutes/day
8	250 minutes/week	50 minutes/day
HS (3 credits)	275 minutes/week	55 minutes/day

Safety Expectations

While there are no specific standards that address laboratory or field safety, it is a required part of science education to instruct and guide students in using appropriate safety precautions for all investigations. Reducing risk and preventing accidents in science classrooms begins with planning that meets all local, state, and federal requirements, including Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) requirements for safe handling and disposal of laboratory materials. The following four steps are recommended for carrying out a hazard and risk assessment for any investigation[5]:

1) Identify hazards. Hazards may be physical, chemical, health, or environmental.
2) Evaluate the type of risk associated with each hazard.
3) Instruct students on all procedures and necessary safety precautions in such a way as to eliminate or reduce the risk associated with each hazard.
4) Prepare for any emergency that might arise despite all the required safety precautions.

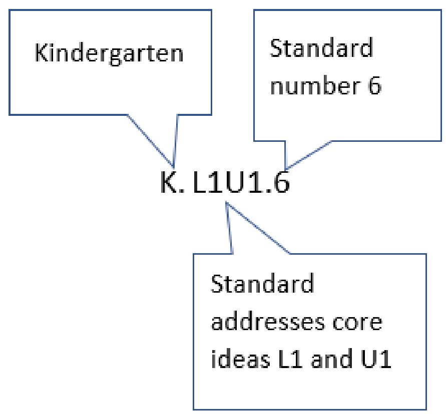
Chemical Storage Expectations

What You Can Do

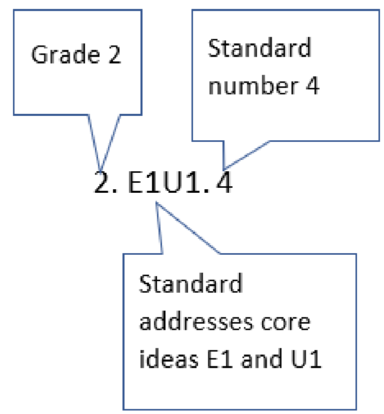
- Put in place an experienced leadership team to oversee chemical management, storage, and handling activities.
- Implement pollution prevention and green chemistry (safer alternatives) principles to minimize the use of hazardous chemicals at schools.
- Establish an environmentally preferable purchasing policy and conduct periodic chemical inventories to identify hazards.
- Train school personnel on hazardous chemicals management and safety.
- Create an emergency response and spill clean-up plan. Communicate with school personnel and students about the plan and the chemicals and products in the school.
- EPA's Chemicals under the Toxic Substance Control Act (TSCA) provides information about this law which protects us from the potential risks of pesticides and toxic chemicals.
- The Center for Disease Control's Facts about Mercury in Schools provides information for school administrators, faculty, staff, local health jurisdictions, and parent groups on how to reduce the hazards of mercury on children's health, avoid chemical liabilities, develop planning tools, and establish collection programs for mercury.
- Chemical Management in Schools is addressed by the Colorado Department of Public Health and Environment, including guidance on self-certification for school laboratories, inventory procedures, lists of common chemical hazards and prohibited or restricted chemicals, and more.
- The School Chemistry Laboratory Safety Guide presents information about ordering, using, storing, and maintaining chemicals in the high school laboratory. The guide also provides information about chemical waste, safety, and emergency equipment, assessing chemical hazards, common safety symbols, signs, and fundamental resources relating to chemical safety, such as Material Safety Data Sheets and Chemical Hygiene Plans, to help create a safe environment for learning. Also, checklists are provided for both teachers and students that highlight important information for working in the laboratory and identify hazards and safe work procedures.

Coding of the K-8 Science Standards

Each K-8 standard represents the intersection of core ideas for knowing science and using science. This intersection stresses that content in physical science, earth and space science, and life science is not learned independently from ideas about the nature of science, applications of science, or the social implications of using science. The coding of the standard captures this intersection. Students engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena, applications, or social implications. They use the crosscutting concepts to support their understanding of patterns, cause and effect relationships, and systems thinking as they make sense of phenomena. The standard number at the end of the code is designed for recording purposes and does not imply instructional sequence or importance. **The images below** are examples and descriptions of coding of the K-8 Standards.



K. L1U1.6. Obtain, evaluate, and communicate information about how organisms use different body parts for survival.



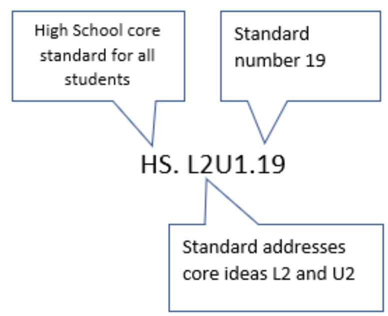
2.E1U1.4. Observe and investigate how wind and water change the shape of the land resulting in a variety of landforms.

Coding of the High School Science Standards

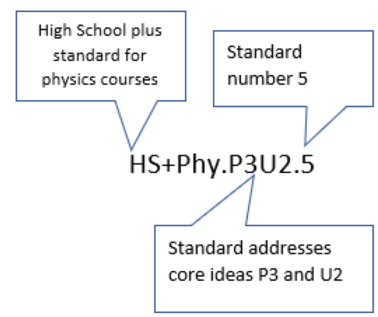
In Arizona, students are required to take 3 credits of high school science aligned to standards in physical, earth and space, and life sciences to meet graduation requirements, but there is no mandatory course sequence across the state. Because of this, the high school standards are written at two levels: essential and plus.

- All high school essential standards (HS) should be learned by every high school student regardless of the 3-credit course sequence they take. The full set of essential high school (HS) standards is designed to be taught over a 3-year period.
- The high school plus (HS+) standards are designed to enhance the rigor of general science courses by extending the essential standards within general chemistry (HS+C), physics (HS+Phy), earth and space sciences (HS+E), or biology (HS+B) courses. These HS+ standards are intended to provide the additional rigor of these courses to prepare students for college courses for science majors.

Like K-8, each high school standard represents the intersection of core ideas for knowing science and using science. This intersection stresses that content in physical science, earth and space science, and life science is not learned independently from ideas about the nature of science, applications of science, or the social implications of using science. The coding of the standard captures this intersection. Students engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena, applications, or social implications. They use the crosscutting concepts to support their understanding of patterns, cause and effect relationships, and systems thinking as they make sense of phenomena. The standard number at the end of the code is designed for recording purposes and does not imply instructional sequence or importance. **At right** are examples and descriptions of coding of the High School Science Standards.



HS. L2U1.19. Develop and use models that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.



HS+Phy.P3U2.6. Design, evaluate, and refine a device that minimizes or maximizes the force on a macroscopic object during a collision.

Navigating the Standards Document

Standards	Support Material
Life Science Standards	**Learning Progressions, Key Terms, and Crosscutting Concepts**
1.L2U2.7	
Develop and use models about how living things use resources to grow and survive; **design and evaluate** habitats for organisms using earth materials.	**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 [4(, 151)] Crosscutting Concepts: **cause and effect;** systems and system models; energy and matter; structure and function; **stability and change** [4]
1.L2U1.8	
Construct an explanation describing how organisms obtain resources from the environment including materials that are used again by other organisms. Concepts taught in K.L1U1.5, K.L4U2.7	

Guide to Explain Standards

Standards

The standards are what is expected for students to master at the end of the grade level and are intended to be the content utilized for the state assessment. They contain the disciplinary core ideas and **the science and engineering practices (SEPs)** that are in bold in the standard. It may take several science and engineering practices to reach the desired level of depth of content. These are expected to be learned over the course of the year throughout multiple standards.	**The Learning Progression, Key Terms, and Crosscutting Concepts** is a guidance resource embedded into the standards document. This is the first step to deepen content knowledge and to make apparent the research behind the standard. The learning progression is supporting material and not the basis for assessment. **The crosscutting concepts listed** connect to other standards for themes and integrated science instruction, one of the key components of three-dimensional science instruction. Bold crosscutting concepts indicate the concepts that are across the grade level. Example: cause and effect and stability and change are dominant crosscutting concepts for first grade.

Support Material

Grades 3-5 Science Standards

The Grades 3-5 Science Standards are designed to provide opportunities for students to develop an understanding of all fourteen core ideas (see Appendix 3) across the 3-5 grade band. To sufficiently demonstrate knowledge, understanding, and performance of each standard, not every core idea is included in every grade.

Within each grade level, students engage in multiple science and engineering practices as they gather information to answer their questions or solve design problems by reasoning how the data provide evidence to support their understanding, and then communicate their understanding of phenomena in physical, earth and space, and life science (the knowing of science). Students apply their knowledge of the core ideas to understand phenomena, see the impact, or construct technological solutions (using science). The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds. The practices, core ideas, and crosscutting concepts help students develop an understanding of skills and knowledge to transfer them from one grade to the next and between content areas.

- In third grade, students develop an understanding of systems and system models along with structure and function involving energy and matter.
- In fourth grade, students apply systems and system models as they investigate how energy and the availability of resources affects the Earth systems (geosphere and biosphere). They also develop an understanding of stability and change with regards to how populations of organisms and the Earth have changed over time.
- In fifth grade, students apply their understanding of scale at micro levels as they investigate changes in matter and at macro levels as they investigate patterns of genetic information and movement between the Earth and Moon.

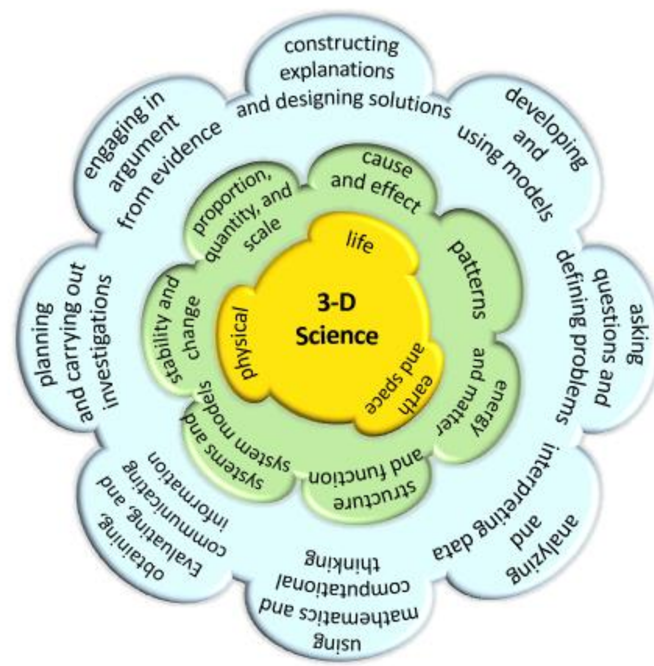


Figure 1: Three Dimensions of Science Instruction

The organization of the standards within this document does not indicate instructional sequence or importance. Decisions about curriculum and instruction are made locally by individual school districts and classroom teachers; these standards can be sequenced, combined, or integrated with other content areas to best meet the local curriculum or student needs (See Appendices 4 and 5). It is suggested to use the metric system for measurement, as most scientific tools utilize the metric system.

Third Grade: Focus on Systems and System Models; Structure and Function

By the end of third grade, students will gain an understanding of how the Sun provides energy for life on Earth. Students apply their understanding of light and sound waves, how they travel, are detected, and transfer energy. Students learn that organisms have different structures and functions which increase their chances of survival. Student investigations focus on collecting and making sense of observational data and simple measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in third grade focus on helping students understand phenomena through systems and system models and structure and function.

Core Ideas for Knowing Science		Core Ideas for Using Science
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it. P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. **Earth and Space Science** E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. **Life Science** L1: Organisms are organized on a cellular basis and have a finite life span. L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. L3: Genetic information is passed down from one generation of organisms to another. L4: The unity and diversity of organisms, living and extinct, is the result of evolution. ***Adapted from *Working with Big Ideas in Science Education*[2]**		U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Sciences: Students develop an understanding of the sources, properties, and characteristics of energy along with the relationship between energy transfer and the human body.

Physical Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
3.P2U1.1	
Ask questions and investigate the relationship between light,-objects, and the human eye. **3.P2U1.2** **Plan and carry out an investigation** to explore how sound waves affect objects at varying distances.	**Light** is seen because it affects the objects it reaches, including our **eyes**. Sources give out light, which travels from them in various directions and is detected when it reaches and enters our eyes. Objects that are seen either **give out** or **reflect** light that human eyes can **detect. Sound** comes from things that **vibrate** and can be detected at a distance from the source because the air or other material around is made to vibrate. Sounds are heard when the vibrations in the air enter our **ears.** [2 (p 21)]. 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. 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.[4 (p. 135)] 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.) [4 (p. 132)] Crosscutting Concepts: patterns; cause and effect; **system and system models;** energy and matter; **structure and function**[4]
3.P4U1.3	
Develop and use models to describe how light and sound waves transfer energy.	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 or light**. (Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.)[4 (p. 122)] 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.[4(p.125)] Crosscutting Concepts: cause and effect; scale, proportion, and quantity; **system and system models;** energy and matter; stability and change[4]

Earth and Space Sciences: Students develop an understanding of how the Sun provides light and energy for ~~the~~ Earth systems.

Earth and Space Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
3.E1U1.4	
Construct an explanation describing how the Sun is the primary source of energy impacting Earth 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. [4 (179-180)] 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.[4 (181)] Crosscutting Concepts: cause and effect; **system and system models;** energy and matter; stability and change[4]

Life Sciences: Students develop an understanding of the flow of energy in a system beginning with the Sun to and among organisms They also understand that plants and animals (including humans) have specialized internal and external structures and can respond to stimuli to increase survival.

Life Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
3.L1U1.5	
Develop and use models to explain that plants and animals (including humans) have internal and external structures that serve various functions that aid in growth, survival, behavior, and reproduction.	Animals have both **internal** and **external** structures that serve various functions in **growth, survival, behavior, and reproduction**. (Boundary: Stress at this grade level focus is on understanding the macroscale systems and their function, not microscopic processes.) [4 (p. 144)] Crosscutting Concepts: scale, proportion and quantity; **system and system models; structure and function;** stability and change[4]
3.L2U1.6	
Plan and carry out investigations to demonstrate ways plants and animals react to stimuli.	
3.L2U1.7	
Develop and use system models to describe the flow of energy from the Sun to and among living organisms.	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. Plants also respond to some external inputs (e.g., turn leaves toward the sun).[4 (p. 149)] Crosscutting Concepts: patterns; cause and effect; **system and system models; structure and function;** stability and change[4]

3.L2U1.8	
Construct an argument from evidence that organisms are interdependent.	**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). [4 (p. 148)] Animals need food that they can break down, which comes either directly by eating plants (**herbivores**) or by eating animals (**carnivores**) which have eaten plants or other animals. Animals are ultimately dependent on plants for their survival. The relationships among organisms can be represented as food chains and food webs. Some animals are dependent on plants in other ways as well as for food, for example for shelter and, in the case of human beings, for clothing and fuel. Plants also depend on animals in various ways. For example, many flowering plants depend on insects for pollination and on other animals for dispersing their seeds.[2 (p. 27)] Crosscutting Concepts: cause and effect; **system and system models;** energy and matter; **structure and function;** stability and change[4]

Fourth Grade: Systems and System Models; Energy and Matter; Stability and Change

By the end of fourth grade, students expand on the idea that energy from the Sun interacts with Earth systems and explore other forms of energy we use in everyday life. Students apply their understanding of the various Earth systems (geosphere, hydrosphere, atmosphere, biosphere) and how they interact with each other and heat from the Sun. Students understand how geological systems change and shape the planet and provide resources. Students also develop an understanding of how Earth processes and human interactions positively and negatively that can change environments impacting the ability for organisms to survive. Student investigations focus on collecting and making sense of observational data and simple measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in fourth grade focus on helping students understand phenomena through systems and system models, energy and matter and stability and change.

Core Ideas for Knowing Science		Core Ideas for Using Science
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it. P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. **Earth and Space Science** E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. **Life Science** L1: Organisms are organized on a cellular basis and have a finite life span. L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. L3: Genetic information is passed down from one generation of organisms to another. L4: The unity and diversity of organisms, living and extinct, is the result of evolution. ***Adapted from *Working with Big Ideas in Science Education*[2]**		U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Sciences: Students develop an understanding of how Earth's resources can be transformed into different forms of energy. Students develop a better understanding of electricity and magnetism.

Physical Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
4.P4U1.1	
Develop and use a model to demonstrate how a system transfers energy from one object to another even when the objects are not touching. **4.P4U1.2** **Develop and use a model** that explains how energy is moved from place to place through electric currents. **4.P2U1.3** **Develop and use a model** to demonstrate magnetic forces. **4.P4U3.4** **Engage in argument from evidence** on the use and impact of renewable and nonrenewable resources to generate electricity.	**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). [4] (p. 125) 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 or light.** (Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.)[4] (p. 122) 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. [4] (p. 125) 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. [4] (p. 129) Crosscutting Concepts: **cause and effect**; **system and system models; energy and matter**[4]

Earth and Space Sciences: Students develop an understanding of the different Earth systems and how they interact with each other. They understand how geological systems change and shape the Earth and the evidence that is used to understand these changes. They also understand how weather, climate, and human interactions can impact the environment.

<table>
<tr><th>Earth and Space Standards</th><th>Learning Progressions, Key Terms, and Crosscutting Concepts</th></tr>
<tr><td>4.E1U1.5</td><td></td></tr>
<tr><td>Use models to explain seismic waves and their effect on the Earth.</td><td rowspan="7">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. 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. [4 (p. 181)] 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. [4 (p. 178)] 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. [4 (p. 188)]</td></tr>
<tr><td>4.E1U1.6</td></tr>
<tr><td>Plan and carry out an investigation to explore and explain the interactions between Earth's major systems and the impact on Earth's surface materials and processes.</td></tr>
<tr><td>4.E1U1.7</td></tr>
<tr><td>Develop and/or revise a model using various rock types, fossil<s>s</s> location, and landforms to show evidence that Earth's surface has changed over time.</td></tr>
<tr><td>4.E1U1.8</td></tr>
<tr><td>Collect, analyze, and interpret data to explain weather and climate patterns.</td></tr>
</table>

4.E1U3.9	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 **freshwater** is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. [4 (p. 185)] 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. [4 (p. 193)] Crosscutting Concepts: cause and effect; **system and system models; energy and matter**; **stability and change**[4]
Construct and support an evidence-based argument about the availability of water and its impact on life. Vertical Alignment: 2.E1U1.5, 2.E1U3.7	
4.E1U2.10	
Define problem(s) and design solution(s) to minimize the effects of natural hazards.	

Life Sciences: Students develop an understanding of the diversity of past and present organisms, factors impacting organism diversity, and evidence of change of organisms over time.

Life Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
4.L4U1.11	
Analyze and interpret environmental **data** demonstrate that species either adapt and survive, or go extinct over time.	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. [4 (p. 155)] **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. [4 (p. 162)] 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. [4 (p. 165)] Crosscutting Concepts: patterns; cause and effect; **system and system models; energy and matter**; **stability and change**[4]

Fifth Grade: Patterns; Scale, Proportion, and Quantity

By the end of fifth grade, students apply their understanding of scale at macro (time and space) and micro (particles of matter) levels to understand patterns and scale across life, earth and space, and physical sciences. Students will develop an–understanding of forces, conservation of matter, and that genetic information can be passed down from parent to offspring. Student investigations focus on collecting and making sense of observational data and measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in fifth grade focus on helping students understand phenomena through patterns and scale, proportion and quantity.

Core Ideas for Knowing Science		Core Ideas for Using Science
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it. P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. **Earth and Space Science** E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. **Life Science** L1: Organisms are organized on a cellular basis and have a finite life span. L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. L3: Genetic information is passed down from one generation of organisms to another. L4: The unity and diversity of organisms, living and extinct, is the result of evolution. ***Adapted from *Working with Big Ideas in Science Education*[2]**		U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Sciences: Students develop an understanding that changes can occur to matter/objects on Earth or in space, but both energy and matter follow the pattern of being conserved during those changes.

Physical Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
5.P1U1.1	
Analyze and interpret data to explain that matter of any type can be subdivided into particles too small to see and, in a closed system, if properties change or chemical reactions occur, the amount of matter stays the same.	**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.) [4] (p. 108) 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.) [4] (pp. 110-111) Other substances simply **mix** without changing permanently and can often be separated again. At room temperature, some substances are in the **solid** state, some in the **liquid** state and some in the **gas** state. The state of many substances can be changed by **heating** or **cooling** them. The amount of matter does not change when a solid **melts** or a liquid **evaporates.** [2] (p. 20) Crosscutting Concepts: **patterns**; **scale, proportion and quantity;** energy and matter[4]
5.P1U1.2	
Plan and carry out investigations to demonstrate that some substances combine to form new substances with different properties and others can be mixed without taking on new properties.	

5.P2U1.3	
Construct an explanation using evidence to demonstrate that objects can affect other objects even when they are not touching.	**Gravity** is the **universal attraction** between all objects, however large or small, although it is only apparent when one of the objects is very large. This gravitational attraction keeps the planets in **orbit** around the **Sun**, the **Moon** round the **Earth** and their moons round other planets. On the Earth it results in everything being pulled down towards the center of the Earth. We call this downward attraction the **weight** of an object. [2 (p. 21)] **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 pull at a distance. [4 (117)] Crosscutting Concepts: cause and effect; **scale, proportion and quantity;** system and system models[4]
5.P3U1.4	
Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects. **5.P3U2.5** **Define problems** and **design solutions** pertaining to force and motion.	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.) [4 (p. 115)] How quickly an object's motion is changed depends on the **force** acting and the object's **mass.** The greater the mass of an object, the longer it takes to speed it up or slow it down, a property of mass described as **inertia.** [2 (p. 22)] Crosscutting Concepts: cause and effect; energy and matter[4]

5.P4U1.6	
Analyze and interpret data to determine how and where energy is transferred when objects move.	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.) [4 (p. 122)] 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). [4 (p. 125)] Crosscutting Concepts: **patterns**; cause and effect; energy and matter[4]

Earth and Space Sciences: Students develop an understanding of the how forces (gravity) in space cause observable patterns due to the position of the Earth, Sun, Moon, and stars.

Earth and Space Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
5.E2U1.7	
Develop, revise, and use models based on evidence to **construct explanations** about the movement of the Earth and Moon within our solar system.	The **Earth** moves round the **Sun** taking about a year for one orbit. The **Moon** orbits the Earth taking about four weeks to complete an orbit. The Sun, at the center of the solar system, is the only object in the solar system that is a source of visible light. The Moon reflects light from the Sun and as it moves round the Earth only those parts illuminated by the Sun are seen. The Earth rotates about an **axis** lying **north** to **south** and this motion makes it appear that the Sun, Moon and stars are moving round the Earth. 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**. 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. [4 (p. 176)] Crosscutting Concepts: **patterns**; system and system models[4]
5.E2U1.8	
Obtain, analyze, and communicate evidence to support an explanation that the gravitational force of Earth on objects is directed toward the planet's center.	**Gravity** is the universal attraction between all objects, however large or small, although it is only apparent when one of the objects is very large. On the Earth it results in everything being pulled down towards the center of the Earth. We call this downward attraction the **weight** of an object. [2 (p. 21)] The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. [4 (p. 117)] Crosscutting Concepts: cause and effect; **scale, proportion, and quantity**[4]

Life Sciences: Students develop an understanding of patterns and how genetic information is passed from generation to generation. They also develop the understanding of how genetic information and environmental features impact the survival of an organism.

Life Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
5.L3U1.9	
Obtain, evaluate, and communicate information about patterns between the offspring of plants, and the offspring of animals (including humans); **construct an explanation** of how genetic information is passed from one generation to the next.	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. [4] (p. 158) 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. [4] (p. 158) 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. (p. 155) 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. [4] (p. 160) Crosscutting Concepts: **patterns**; cause and effect; structure and function; stability and change[4]
5.L3U1.10	
Construct an explanation based on evidence that the changes in an environment can affect the development of the traits in a population of organisms.	
5.L4U3.11	
Obtain, evaluate, and communicate evidence about how natural and human-caused changes to habitats or climate can impact populations.	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. [4] (p. 165) 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. [4] (p. 165) Crosscutting Concepts: **patterns**; cause and effect; stability and change[4]

5.L4U3.12	
Construct an argument based on evidence that inherited characteristics can be affected by behavior and/or environmental conditions.	Sometimes the differences in **characteristics** between individuals of the same **species** provide advantages in surviving, finding **mates**, and **reproducing**. 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. [4] (p. 158) Crosscutting Concepts: **patterns**; cause and effect; stability and change[4]

Distribution of Grades 3-5 Standards

	U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.	U2: The knowledge produced by science is used in engineering and technologies to create products.	U3: Applications of science often have both positive and negative ethical, social, economic, and political implications.
P1: All matter in the Universe is made of very small particles.	5.P1U1.1 5.P1U1.2		
P2: Objects can affect other objects at a distance.	3.P2U1.1 3.P2U1.2 4.P2U1.3 5.P2U1.3		
P3: Changing the movement of an object requires a net force to be acting on it.	5.P3U1.4	5.P3U2.5	
P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.	3.P4U1.3 4.P4U1.1 4.P4U1.2 5.P4U1.6		4.P4U3.4
E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.	3.E1U1.4 4.E1U1.5 4.E1U1.6 4.E1U1.7 4.E1U1.8	4.E1U2.10	4.E1U3.9
E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.	5.E2U1.7 5.E2U1.8		
L1: Organisms are organized on a cellular basis and have a finite life span.	3.L1U1.5		
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.	3.L2U1.6 3.L2U1.7 3.L2U1.8		
L3: Genetic information is passed down from one generation of organisms to another.	5.L3U1.9 5.L3U1.10		
L4: The unity and diversity of organisms, living and extinct, is the result of evolution.	4.L4U1.11		5.L4U3.11 5.L4U3.12

Appendices

Appendix 1: Crosscutting Concepts

The seven crosscutting concepts bridge disciplinary boundaries and unite core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the core ideas in the standards and develop a coherent and scientifically based view of the world. Students should make explicit connections between their learning and the crosscutting concepts within each grade level.

These concepts also bridge the boundaries between science and other disciplines. As educators focus on crosscutting concepts, they should look for ways to integrate them into other disciplines. For example, patterns are highly prevalent in language. Indeed, phonics, an evidence-based literacy instructional strategy, is specifically designed to assist students in recognizing patterns in language. By actively incorporating these types of opportunities, educators assist students in building connections across content areas to deepen and extend learning.

The crosscutting concepts and their progressions from *Chapter 4 Crosscutting concepts pages 83 - 102 in A Framework for K-12 Science Education*[4] are summarized below.

Patterns*: Observed patterns of forms and events guide organization and classification and prompt questions about relationships and the factors that influence them.*
Patterns are often a first step in organizing and asking scientific and engineering questions. In science, classification is one example of recognizing patterns of similarity and diversity. In engineering, patterns of system failures may lead to design improvements. Assisting children with pattern recognition facilitates learning causing the brain to search for meaning in real-world phenomena.[1] Pattern recognition progresses from broad similarities and differences in young children to more detailed, scientific descriptors in upper elementary. Middle school students recognize patterns on both the micro- and macroscopic levels, and high school students understand that patterns vary in a system depending upon the scale at which the system is studied.
Cause and effect: Events have causes, sometimes simple, sometimes multifaceted. A major activity of both science and engineering 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.
Like patterns, a child's ability to recognize cause and effect relationships progresses as they age. In the early grades, students build upon their understanding of patterns to investigate the causes of these patterns. They may wonder what caused one seed to grow faster than another one and design a test to gather evidence. By upper elementary, students should routinely be asking questions related to cause and effect. In middle school, students begin challenging others' explanations about causes through scientific argumentation. High school continues this trend while students expand their investigation into mechanisms that may

have multiple mediating factors such as changes in ecosystems over time or mechanisms that work in some systems but not in others.
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.
There are two major scales from which we study science: directly observable and those processes which required tools or scientific measurement to be quantified and studied. To understand scale, students must understand both measurement and orders of magnitude. Understanding of scale, proportion, and quantity will progress as children get older. Young children engage in relative measures such as hotter/colder, bigger/smaller, or older/younger without referring to a specific unit of measure. As students age, it is important that they recognize the need for a common unit of measure to make a judgement of scale, proportion, and quantity. Elementary students start building this knowledge through length measurements and gradually progress to weight, time, temperature or other variables. Intersection with key mathematical concepts is vital to help students develop the ability to assign meaning to ratios and proportions when discussing scale, proportion, and quantity in science and engineering. By middle and high school, students apply this knowledge to algebraic thinking and are able to change variables, understand both linear and exponential growth, and engage in complex mathematical and statistical relationships.
Systems and system models: Because the world is too large and complex to comprehend all at once, students must define the system under study, specify its boundaries, and make explicit a model of that system provides tools for understanding and testing ideas that are applicable throughout science and engineering.
Models of systems can also be useful in conveying information about that system to others. Many engineering designs start with system models as a way to predict outcomes and test theories prior to final development ensuring that interactions between system parts and subsystems are understood. As students age, their ability to analyze and predict outcomes strengthens. In the early grades, students should be asked to express systems thinking through drawings, diagrams, or oral explanations noting relationships between parts. Additionally, even at a young age, students can be asked to develop plans for their actions or sets of instructions to help them develop the concept that others should be able to understand and use them. As student's age, they should incorporate more facets of the system including those facets which are not visible such as energy flow. By high school, students can identify the assumptions and approximations that went into making the system model and discuss how these assumptions and approximations limit the precision and reliability of predictions.
Energy and matter: Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

The concept of conservation of energy within a closed system is complex and prone to misunderstanding. As a result, students in early elementary are only very generally exposed to the concept of energy. In the early grades, focus on the recognition of conservation of matter within a system and the flow of matter between systems builds the basis for understanding more complex energy concepts in later grades. In middle school and high school, students develop a deeper understanding of this concept through chemical reactions and atomic structure. In high school, nuclear processes are introduced along with conservation laws related specifically to nuclear processes.
Structure and function: The way in which an object or living thing is shaped and its substructure determines many of its properties and functions.
Knowledge of structure and function is essential to successful design. As such, it is important that students begin an investigation of structure and function at an early age. In early grades, this study takes the form of how shape and stability are related for different structures: braces make a bridge stronger, a deeper bowl holds more water. In upper elementary and middle school, students begin an investigation of structures that are not visible to the naked eye: how the structure of water and salt molecules relate to solubility, the shape of the continents and plate tectonics. In high school students apply their knowledge of the relationship of structure to function when investigating the structure of the heart and the specific function it performs.
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.
When systems are stable, small disturbances fade away, and the system returns to the stable condition. In maintaining a stable system, whether it is a natural system or a human design, feedback loops are an essential element. Young children experiment with stability and change as they build with blocks or chart growth. As they experiment with these concepts, the educator should assist them in building associated language and vocabulary as well as learning to question why some things change, and others stay the same. In middle school, understanding of stability and change extends beyond those phenomena which are easily visible to more subtle form of stability and change. By high school, students bring in their knowledge of historical events to explain stability and change over long periods of time, and they also recognize that multiple factors may feed into these concepts of stability and change.

Appendix 2: Science and Engineering Practices

The science and engineering practices describe how scientists investigate and build models and theories of the natural world or how engineers design and build systems. They reflect science and engineering as they are practiced and experienced. As students conduct investigations, they engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding and then communicate their understanding of phenomena. Student investigations may be observational, experimental, use models or simulations, or use data from other sources. These eight practices identified in *Chapter 4 of A Framework for K-12 Science Education*[4] are critical components of scientific literacy. They are not instructional strategies.

Distinguishing Science & Engineering Practices

	Science	Engineering
Ask Questions and Define Problems	Science often 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. Scientists formulate empirically answerable questions about phenomena; they establish what is already known and determine what questions have yet to be satisfactorily answered.	Engineering begins with a problem, need, or desire that suggests a problem that needs to be solved. A problem such as reducing the nation's dependence on fossil fuels may produce multiple engineering problems like designing efficient transportation systems or improved solar cells. Engineers ask questions to define the problem, determine criteria for a successful solution, and identify constraints.
Develop and Use Models	Science often involves constructing and using a variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond what can be observed. Models enable predictions to be made to test hypothetical explanations.	Engineering uses models and simulations to analyze existing systems to see where flaws might occur or to test viable solutions to a new problem. Engineers use models of various sorts to test proposed systems and to recognize the strengths and limitations of their designs.
Plan and Carry Out Investigations	Scientific investigations may be conducted in the field or the laboratory. Scientists plan and carry out systematic investigations that require the identification of what is to be recorded and, if applicable, what are to be treated as the dependent and independent variables. Observations and data collected are used to test existing theories and explanations or to revise and develop new ones.	Engineers use investigations to gather data essential for specifying design criteria or parameters and to test their designs. 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.

Analyze and Interpret Data	Scientific investigations produce data that must be analyzed 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 significant features and patterns in the data, sources of error, and the calculated degree of certainty. Technology makes collecting large data sets easier providing many secondary sources for analysis.	Engineers analyze data collected during 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. Engineers require a range of tools to identify the major patterns and interpret the results.
Use 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: constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable the behavior of physical systems to be predicted and tested. Statistical techniques are invaluable for assessing the significance of patterns or correlations.	In engineering, mathematical and computational representations of established relationships and principles are a fundamental 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. Simulations of designs provide an effective test bed for the development.
Construct Explanations and Design Solutions	In science, theories are constructed to provide explanatory accounts of phenomena. 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. Scientific explanations are explicit applications of theory to a specific situation or phenomenon, perhaps with 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 is a systematic process for solving engineering problems and 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, feasibility, cost, safety, aesthetics, and compliance with legal requirements. There is usually no single best solution but rather a range of solutions. The optimal solution often depends on the criteria used for making evaluations.
Engage in Argument from Evidence	In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of thinking and for finding the best explanation for a	In engineering, reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design

	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.	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 to achieve the best solution to the problem at hand.
Obtain, Evaluate, and Communicate Information	Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or to learn about the findings of others. Scientists need to express their ideas, orally and in writing, using tables, diagrams, graphs, drawings, equations, or models and by engaging in discussions with peers. Scientists need to be able to derive meaning from texts (such as papers, the internet, symposia, and lectures) to evaluate the scientific validity of the information and to integrate that information with existing theories or explanations. Scientists routinely use technologies to extend the possibilities for collaboration and communication.	Engineers cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to express their ideas, orally and in writing, using tables, graphs, drawings, or models and by engaging in discussions with peers. Engineers need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. Engineers routinely use technologies to extend the possibilities for collaboration and communication.

[4]Adapted from Box 3-2, National Research Council. pages 50-53

Appendix 3: Core Ideas

The core ideas encompass the content that occurs at each grade and provides the background knowledge for students to develop sense-making around phenomena. The core ideas center around understanding the causes of phenomena in physical, earth and space, and life science; the principles, theories, and models that support that understanding; engineering and technological applications; and societal implications. The Arizona Science Standards integrate learning progressions from *A Framework for K-12 Science Education* [4] to build a coherent progression of learning for these core ideas from elementary school through high school. The following fourteen big ideas for knowing science and using science are adapted from *Working with Big Ideas of Science Education*[2] and represent student understanding of each core idea at the end of high school.

Core Ideas for Knowing Science	
P1: All matter in the Universe is made of very small particles.	Atoms are the building blocks of all normal matter, living and nonliving. The behavior and arrangement of the atoms explains the properties of different materials. In chemical reactions atoms are rearranged to form new substances. Each atom has a nucleus, containing neutrons and protons, surrounded by electrons. The opposite electric charges of protons and electrons attract each other, keeping atoms together and accounting for the formation of some compounds.
P2: Objects can affect other objects at a distance.	All objects have an effect on other objects without being in contact with them. In some cases, the effect travels out from the source to the receiver in the form of radiation such as visible light. In other cases, action at a distance is explained in terms of the existence of a field of influence between objects, such as a magnetic, electric, or gravitational field. Gravity is a universal force of attraction between all objects, however large or small, keeping the planets in orbit around the Sun and causing terrestrial objects to fall towards the center of the Earth.
P3: Changing the movement of an object requires a net force to be acting on it.	A force acting on an object is not seen directly but is detected by its effect on the object's motion or shape. If an object is not moving, the forces acting on it are equal in size and opposite in direction, balancing each other. Since gravity affects all objects on Earth, there is always another force opposing gravity when an object is at rest. Unbalanced forces cause change in movement in the direction of the net force. When opposing forces acting on an object are not in the same line they cause the object to turn or twist. This effect is used in some simple machines.
P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.	The total amount of energy in the Universe is always the same but can be transferred from one energy store to another during an event. Many processes or events involve changes and require an energy source to make them happen. Energy can be transferred from one body or group of bodies to another in various ways. In these processes, some energy becomes less easy to use. Energy cannot be created or destroyed.

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.	Radiation from the Sun heats the Earth's surface and causes convection currents in the air and oceans creating climates. Below the surface, heat from the Earth's interior causes movement in the molten rock. This in turn leads to movement of the plates which form the Earth's crust, creating volcanoes and earthquakes. The solid surface is constantly changing through the formation and weathering of rock.
E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.	Our Sun and eight planets and other smaller objects orbiting it comprise the solar system. Day and night and the seasons are explained by the orientation and rotation of the Earth as it moves round the Sun. The solar system is part of a galaxy of stars, gas, and dust. It is one of many billions in the Universe, enormous distances apart. Many stars appear to have planets.

L1: Organisms are organized on a cellular basis and have a finite life span.	All organisms are constituted of one or more cells. Multicellular organisms have cells that are differentiated according to their function. All the basic functions of life are the result of what happens inside the cells which make up an organism. Growth is the result of multiple cell divisions.
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.	Food provides materials and energy for organisms to carry out the basic functions of life and to grow. Green plants and some bacteria are able to use energy from the Sun to generate complex food molecules. Animals obtain energy by breaking down complex food molecules and are ultimately dependent on producers as their source of energy. In any ecosystem, there is competition among species for the energy resources and materials they need to live and reproduce.
L3: Genetic information is passed down from one generation of organisms to another.	Genetic information in a cell is held in the chemical DNA. Genes determine the development and structure of organisms. In asexual reproduction all the genes in the offspring come from one parent. In sexual reproduction half of the genes come from each parent.
L4: The unity and diversity of organisms, living and extinct, is the result of evolution.	All life today is directly descended from a universal common ancestor. Over countless generations changes resulting from natural diversity within a species are believed to lead to the selection of those individuals best suited to survive under certain conditions. Species not able to respond sufficiently to changes in their environment become extinct.

Core Ideas for Using Science	
U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.	**Science's purpose is to find the cause or causes of phenomena in the natural world.** Science is a search to explain and understand phenomena in the natural world. There is no single scientific method for doing this; the diversity of natural phenomena requires a diversity of methods and instruments to generate and test scientific explanations. [2] (p. 30) **Scientific explanations, theories, and models are those that best fit the evidence available at a particular time.** A scientific theory or model representing relationships between variables of a natural phenomenon must fit the observations available at the time and lead to predictions that can be tested. Any theory or model is provisional and subject to revision in the light of new data even though it may have led to predictions in accord with data in the past. [2] (31)
U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.	The use of scientific ideas in engineering and technologies has made considerable changes in many aspects of human activity. Advances in technologies enable further scientific activity; in turn, this increases understanding of the natural world. In some areas of human activity technology is ahead of scientific ideas, but in others scientific ideas precede technology. [2] (p. 32)
U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.	The use of scientific knowledge in technologies makes many innovations possible. Whether particular applications of science are desirable is a matter that cannot be addressed using scientific knowledge alone. Ethical and moral judgments may be needed, based on such considerations as personal beliefs, justice or equity, human safety, and impacts on people and the environment. [2] (p. 33)

Appendix 4: Equity & Diversity in Science

All students can and should learn complex science. However, achieving equity in science education is an ongoing challenge. Students from underrepresented communities often face "opportunity gaps" in their educational experience. Inclusive approaches to science instruction can reposition youth as meaningful participants in science learning and recognize their science-related assets and those of their communities[4].

The science and engineering practices have the potential to be inclusive of students who have traditionally been marginalized in the science classroom and may not see science as being relevant to their lives or future. These practices support sense-making and language use as students engage in a classroom culture of discourse[6]. The science and engineering practices can support bridges between literacy and numeracy needs, which is particularly helpful for non-dominant groups when addressing multiple "opportunity gaps." By solving problems through engineering in local contexts (gardening, improving air quality, cleaning water pollution in the community), students gain knowledge of science content, view science as relevant to their lives and future, and engage in science in socially relevant and transformative ways[7]. Science teachers need to acquire effective strategies to include all students regardless of age, racial, ethnic, cultural, linguistic, socioeconomic, and gender backgrounds[3].

Effective teaching strategies[3] for attending to equity and diversity for

- **Economically disadvantaged students** include (1) connecting science education to students' sense of "place" as physical, historical, and sociocultural dimensions in their community; (2) applying students' "funds of knowledge" and cultural practices; and (3) using problem-based and project-based science learning centered on authentic questions and activities that matter to students.
- **Underrepresented racial and ethnic groups** include (1) culturally relevant pedagogy, (2) community involvement and social activism, (3) multiple representations and multimodal experiences, and (4) school support systems including role models and mentors of similar racial or ethnic backgrounds.
- **Indigenous students** include (1) learning and knowing that is land- and place-based, (2) centers (not erases or undermines) their ways of knowing, and (3) builds connections between Indigenous and western Science Technology Engineering and Mathematics (STEM), and (4) home culture connections[8].
- **Students with disabilities** include (1) multiple means of representation, (2) multiple means of action and expression, (3) multiple means of engagement, (4) concrete experiences with realia, and (5) scaffolds in problem-based and project-based learning.
- **English language learners** include (1) literacy strategies for all students, (2) language support strategies with English language learners, (3) discourse strategies with English language learners, (4) home language support, (5) home culture connections, (6) concrete experiences with realia, and (7) scaffolds in problem-based and project-based learning.
- **Alternative education setting for dropout prevention** include (1) structured after-school opportunities, (2) family outreach, (3) life skills training, (4) safe learning environment, and (5) individualized academic support.
- **Girls' achievement, confidence, and affinity with science** include (1) instructional strategies, (2) curricular decisions, and (3) classroom and school structure.
- **Gifted and talented students** include (1) different levels of challenge (including differentiation of content), (2) opportunities for self-direction, and (3) strategic grouping.

Appendix 5: Interdisciplinary Connections

The crosscutting concepts along with the science and engineering practices provide opportunities for developing strong interdisciplinary connections across all content areas. Understanding core ideas in science can provide a context for helping students master key competencies from other content areas. It can also promote essential career readiness skills, including communication, creativity, collaboration, and critical thinking. This affords all students equitable access to learning and ensures all students are prepared for college, career, and citizenship.

English Language Arts
The science and engineering practices incorporate reasoning skills used in language arts to help students improve mastery and understanding in reading, writing, speaking, and listening. The intersections between science and ELA teach students to analyze data, model concepts, and strategically use tools through productive talk and shared activity. Evidence-based reasoning is the foundation of good scientific practice. Reading, writing, speaking, and listening in science requires an appreciation of the norms and conventions of the discipline of science, including understanding the nature of evidence used, an attention to precision and detail, and the capacity to make and assess intricate arguments, verbally and orally present findings, synthesize complex information, and follow detailed procedures and accounts of events and concepts. To support these disciplinary literacy skills, teachers must foster a classroom culture where students think and reason together, connecting around the core ideas, science and engineering practices, and the crosscutting concepts.

Mathematics
Science is a quantitative discipline, so it is important for educators to ensure that students' science learning coheres well with their understanding of mathematics.[5] Mathematics is fundamental to aspects of modeling and evidence-based conclusions. It is essential for expressing relationships in quantitative data. The Standards for Mathematical Practice (MP) naturally link to the science and engineering practices and multiple crosscutting concepts within the Arizona Science Standards. By incorporating the Arizona Mathematics Standards and practices with critical thinking in science instruction, educators provide students with opportunities to develop literacy in mathematics instruction. The goal of using mathematical skills and practices in science is to foster a deeper conceptual understanding of science.

Health
Natural connections between Health and science exist throughout the Standards. The goals of Health being to maintain and improve students' health, prevent disease, and avoid or reduce health-related risk behaviors which can fit within the context of science standards.

Computer Science
Natural connections between science and computer science exist throughout the Standards, especially in the middle level and in high school. As students develop or refine complex models and simulations of natural and designed systems, they can use computer science to develop, test, and use mathematical or computational models to generate data. Students can apply computational thinking and coding to develop apps or streamline processes for collecting, analyzing, or interpreting data.

Technology
Technology is essential in teaching and learning science; it influences the science that is taught and enhances students' learning. Technologies in science run the range from tools for performing experiments or collecting data (thermometers, temperature probes, microscopes, centrifuges) to digital technologies for completing analysis or displaying data (calculators, computers). All of them are essential tools for teaching, learning, and doing science. Computers and other digital tools allow students to collect, record, organize, analyze, and communicate data as they engage in science learning. They can support student investigations in every area of science. When technology tools are available, students can focus on decision making, reflection, reasoning, and problem solving. Connections to engineering, technology, and applications of science are included at all grade levels and in all domains. These connections highlight the interdependence of science, engineering, and technology that drives the research, innovation, and development cycle where discoveries in science lead to new technologies developed using the engineering design process. Additionally, these connections call attention to the effects of scientific and technological advances on society and the environment.

<u>Social Studies</u>
Natural connections between the core ideas for using science and social studies exist throughout the Standards. Students need a foundation in social studies to understand how ethical, social, economic, and political issues of the past and present impact the development and communication of scientific theories, engineering and technological developments, and other applications of science and engineering. Students can use historical, geographic, and economic perspectives to understand that all cultures have ways of understanding phenomena in the natural world and have contributed and continue to contribute to the fields of science and engineering. Sustainability issues and citizen science provide contemporary contexts for integrating social studies with science. Citizen science is the public involvement in inquiry and discovery of new scientific knowledge. This engagement helps students build science knowledge and skills while improving social behavior, increasing student engagement, and strengthening community partnerships. Citizen science projects enlist K-12 students to collect or analyze data for real-world research studies, which helps students develop a deep knowledge of geography, economics, and civic issues of specific regions.

Appendix 6: Connections to English Language Arts and Math

Kindergarten - 2nd Grade

	Kindergarten	1st Grade	2nd Grade
Arizona English Language Arts	Use age-appropriate scientific texts and biographies to develop instruction that integrates the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards		
Arizona Mathematics Standards	**Standards for Mathematical Practices** -Make sense of problems and persevere in solving them -Use appropriate tools strategically -Look for and make use of structure -Look for and express regularity in repeated reasoning **Counting and Cardinality** -Develop competence with counting and cardinality -Develop understanding of addition and subtraction within 10 **Measurement and Data** -Describe and compare measurable attributes -Classify objects and count the number of objects in each category	**Standards for Mathematical Practice** -Make sense of problems and persevere in solving them -Use appropriate tools strategically -Construct viable arguments and critique the reasoning of others -Attend to precision -Look for and make use of structure -Look for and express regularity in repeated reasoning **Measurement and Data** -Measure lengths indirectly and by iterating length units -Represent and interpret data **Geometry** -Reason with shapes and their attribute	**Standards for Mathematical Practice** -Make sense of problems and persevere in solving them -Use appropriate tools strategically -Construct viable arguments and critique the reasoning of others. -Attend to precision -Look for and make use of structure -Look for and express regularity in repeated reasoning **Operations and Algebraic Thinking** -Represent and solve problems involving addition and subtraction **Number and Operations in Base Ten** -Use place value understanding and properties of operations to add and subtract **Measurement and Data** -Represent and interpret data -Measure the length of an object using an appropriate tool including metrics.

3rd Grade - 5th Grade

	3rd Grade	4th Grade	5th Grade
Arizona English Language Arts	Use age-appropriate scientific texts and biographies to develop instruction that integrates the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards		
Arizona Mathematics Standards	**Standards for Mathematical Practices** -Make sense of problems and persevere in solving them -Reason abstractly and quantitatively -Use appropriate tools strategically -Construct viable arguments and critique the reasoning of others -Use appropriate tools strategically -Attend to precision -Look for and make use of structure **Operations and Algebraic Thinking** -Represent and solve problems involving addition and subtraction **Number and Operations in Base Ten** -Use place value understanding and properties of operations to perform multi-digit arithmetic **Number and Operations - Fractions** -Understand fractions as numbers **Measurement and Data** -Measure and estimate liquid volumes and masses of objects -Solve problems involving measurement -Represent and interpret data	**Standards for Mathematical Practice** -Make sense of problems and persevere in solving them -Use appropriate tools strategically -Construct viable arguments and critique the reasoning of others -Attend to precision -Look for and make use of structure -Look for and express regularity in repeated reasoning **Operations and Algebraic Thinking** -Use place value understanding and properties of operations to perform multi-digit arithmetic **Number and Operations in Base Ten** **Number and Operations - Fractions** -Understand decimal notation for fractions and compare decimal fractions **Measurement and Data** -Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit -Represent and interpret data	**Standards for Mathematical Practice** -Make sense of problems and persevere in solving them reason abstractly and quantitatively -Construct viable arguments and critique the reasoning of other -Model with mathematics -Use appropriate tools strategically -Attend to precision -Look for and make use of structure -Look for and express regularity in repeated reasoning **Operations and Algebraic Thinking** -Write and interpret numerical expressions. -Analyze patterns and relationships **Measurement and Data** -Convert like measurement units within a given measurement system -Represent and interpret data -Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit -Solve problems involving measurement -Geometric measurement; understand concepts of volume and relate volume to multiplication and division.

6th Grade - 8th Grade

	6th Grade	7th Grade	8th Grade
Arizona English Language Arts	Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Use age-appropriate scientific texts and biographies to develop instruction that integrates the Reading Standards for Informational Text, and the Writing Standards		
Arizona Mathematics Standards	**Standards for Mathematical Practices** -Make sense of problems and persevere in solving them -Reason abstractly and quantitatively -Use appropriate tools strategically -Construct viable arguments and critique the reasoning of others -Use appropriate tools strategically -Attend to precision -Look for and make use of structure -Model with mathematics -Look for and express regularity in repeated reasoning **Ratios and Proportional Relationships** -Understand ratio concepts and use ratio reasoning to solve problems **Expressions and Equations** -Represent and analyze quantitative relationships between dependent and independent variable **Geometry** -Solve mathematical problems and problems in real-world context involving area, surface area and volume	**Standards for Mathematical Practice** -Make sense of problems and persevere in solving them -Reason abstractly and quantitatively -Use appropriate tools strategically -Construct viable arguments and critique the reasoning of others -Attend to precision -Look for and make use of structure -Look for and express regularity in repeated reasoning -Model with mathematics **Statistics and Probability** -Use random sampling to draw inferences about a population -Draw informal comparative inferences about two populations -Investigate chance processes and develop, use, and evaluate probability models	**Standards for Mathematical Practice** -Make sense of problems and persevere in solving them -Reason abstractly and quantitatively -Use appropriate tools strategically -Construct viable arguments and critique the reasoning of others. -Attend to precision -Look for and make use of structure -Look for and express regularity in repeated reasoning -Model with mathematics **Expressions and Equations** -Understand the connections between proportional relationships, lines, and linear equations **Functions** -Use functions to model relationships between quantities **Statistics and Probability** -Investigate patterns of association in bivariate data -Investigate chance processes and develop, use, and evaluate probability models

References

[1]Barkman, R.C. (2000, November). *Patterns, the Brain, and Learning*. Retrieved February 16, 2018, from http/www.ascd.org/publications/classroom-leadership/nov2000/Patterns,-the-Brain,-and-Learning.aspx.

[2]Harlen, W. (2015) *Working with Big Ideas of Science Education*. Global Network of Science Academies (IAP) Science Education Programme: Trieste, Italy.

[3] Lee, O., & Buxton, C. A. (2010). *Diversity and equity in science education: Theory, research, and practice.* New York: Teachers College Press.

[4] National Research Council (NRC). (2012). *A Framework for K-12 Science Education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academies Press.

[5]National Science Teachers Association. (2015, October). National Science Teachers Association. Retrieved June 13, 2018, from NSTA Position Statement: Safety and School Science Instruction: http://www.nsta.org/about/positions/safety.aspx

[6]NGSS Lead States. (2013) *Next Generation Science Standards: For States, By State*s. Appendix D Case Studies. Washington, DC: The National Academies Press.

[7]Quinn H., Lee O., Valdés G. (2012). Language demands and opportunities in relation to next generation science standards for English language learners: What teachers need to know. Paper presented at the Understanding Language Conference, Stanford, CA. Retrieved November 15, 2017 from http://ell.stanford.edu/sites/default/files/pdf/academic-papers/03-Quinn%20Lee%20Valdes%20Language%20and%20Opportunities%20in%20Science%20FINAL.pdf

[8] Rodriguez, A. J., & Berryman, C. (2002). Using sociotransformative constructivism to teach for understanding in diverse classrooms: A beginning teacher's journey. *American Educational Research Journal, 39*, 1017-1045.

[9] Spang, M. & Bang, C. A. (2014) *Practice Brief #11: Implementing Meaningful STEM Education with Indigenous Students & Families*. Retrieved November 15, 2017 from http://stemteachingtools.org/brief/11.